International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 10, Issue 7 (July 2014), PP.69-75

Performance Analysis of Fused Eye Vein and Finger Vein Multimodal Biometric System

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Abstract:- In recent years, biometric authentication has become one of the popular strategy for various applications like ATMs, online banking, e-commerce websites etc., New biometric modalities are currently being tested and implemented. In this paper, a relatively new paradigm using fusion of biometric images eye vein and finger vein is proposed. Though different multimodalities exist this combination is unique and gives promising results and hence can be considered in future as a positive biometric trait. The proposed approach is based on the fusion of the two traits by extracting independent feature pointsets from the two modalities and making them compatible for concatenation. The concatenated feature pointset has better discrimination power than the individual feature vectors. The proposed eye vein and finger vein fused template was evaluated using publicly available UBIRIS, IUPUI and SDUMLA-HMT multi wavelength database. The experimental results show that this technique is efficient and provides accurate identity verification than other biometric traits.

Keywords:- Biometrics, Multimodal, Eye vein, Sclera, Fingervein, Authentication.

I. INTRODUCTION

User authentication is extremely important for computer and network system security. Currently, knowledge based methods and token based methods are the most popular approaches. However, these methods have a number of security flaws. For example, passwords can be easily shared, stolen, and forgotten. Similarly, smart cards can be shared, stolen, duplicated, or lost. To circumvent these issues, a number of login authentication methods, including textual, graphical passwords and biometric authentication have been utilized.

Some of the commonly used hard biometrics is Face, Sclera, Fingerprint, Iris, Fingervein etc. Soft biometrics includes Keystroke, Voice, Cloth colour, facial colour etc. A unimodal technique [3] is not sufficient to authenticate a user because the system sometimes cannot observe the biometric information correctly. To address the limitations of single biometrics, using multimodal biometrics is a good solution. It is the combination of two or more biometric traits to raise systems security and reliability.

Multimodal Biometrics[1] system is capable of using more than one physiological or behavioural characteristic for enrolment, verification or identification. For biometric identification to be ultra-secure and provide above average accuracy, more than one type must be used as only one form of it may not be accurate enough. One example of this inaccuracy is in the area of fingerprints where at least 10% of people have worn, cut or unrecognizable prints. Combining the results obtained by different biometric traits by an effective fusion scheme can significantly improve the overall accuracy of the biometric system. The proposed work includes eye vein and Fingervein as shown in Fig.1 with their Multimodal biometric traits for authentication of the user. The blood vessel structure of the sclera is unique to each person, and it can be remotely obtained in the visible wavelengths.

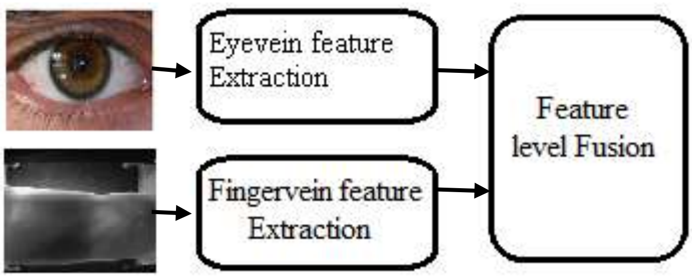


Fig.1: Multimodal biometrics of Eye vein and Finger vein

Finger vein authentication is a new biometric method utilizing the vein patterns inside one's fingers for personal identity verification. Unlike some biometric systems, blood vessel patterns are almost impossible to counterfeit because they are located beneath the skin's surface. These unique aspects of finger vein pattern recognition set it apart from previous forms of biometrics. The most vulnerable part of the vein system is that there are some factors like body temperature, ambient temperature, humidity, camera calibration and focus that may affect the quality of the image, which in turn will affect the verification rate. The finger print and iris system also has considerable weaknesses - it is not that resistant to spoof attack, as they are physical entities.

The proposed work uses multimodal biometrics of sclera blood vein pattern and fingervein. For login users can use the cryptographic key generated from the fused template of sclera blood veins and fingervein as they are unique to each individual and it is more accurate than any other biometric. The experimental results show that sclera recognition is a promising new biometrics for positive human ID. A new method for sclera segmentation which works for both colour and grayscale images is proposed and, we designed a Gabor wavelet-based sclera pattern enhancement method to emphasize and binarize the sclera vessel patterns.

During verification the sclera [7] and fingervein images of the user are taken as input through respective sensors and compared with the information stored in the database to verify automatically the identity of its owner. In other words, this mechanism allows to verify quickly the claimed identity of the person holding the paper document (such as an admission ticket), without requiring human intervention, by just comparing locally the output of his/her biometric trait with the data stored in the document itself. There are few typical scenarios for this application. For example, there are several cases of money transaction through banks and cockpit in planes can be controlled through this authentication. This authentication can be used in the diplomatic passports for higher officials holding important positions as shown in Fig.2.

In addition, the cryptographic key generated from biometric data can also be secured within the ATM cards which can be verified during their transaction. Latest mobile phones and laptops can be featured with high resolution cameras and finger vein reader to enable its users to authenticate easily. This type of authentication can be used for high security access like military, research centres, scientific organisations etc.

Fig.2: Finger vein and Eye vein imaging systems

II. EXTRACTION OF EYE VEIN

Sclera is the white portion surrounding the eye as opaque outer protective covering of the eye as shown in Fig.3. Extraction of sclera vessel pattern is to identify and extract the vein portions of sclera from the original eye image for processing and identification.

To segment the sclera from eye image the process involved are segment sclera, extract sclera features and enhance the vessel patterns, matching the features of sclera veins, and decision matching[8]. First we have to downsample the UBIRIS database image, this downsampling reduces the size of original image to required size. The image is converted from the RGB colorspace to HSV colorspace. Second, detect the eyelid boundary and segment iris region using active contour method. Gabor filter is used for extraction of vein pattern from the segmented sclera region and enhanced. The enhanced vein patterns are thresholded using an adaptive threshold method to emphasize and binarize the sclera vein pattern, and thinned to a pixel wide skeleton using morphological operations as shown in Fig.4.

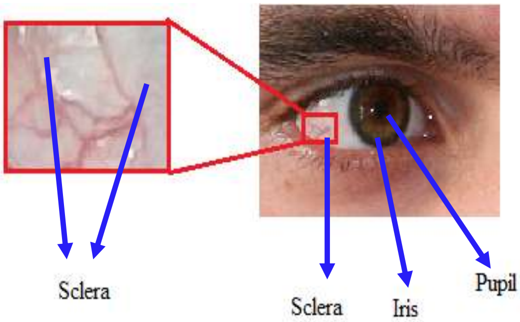
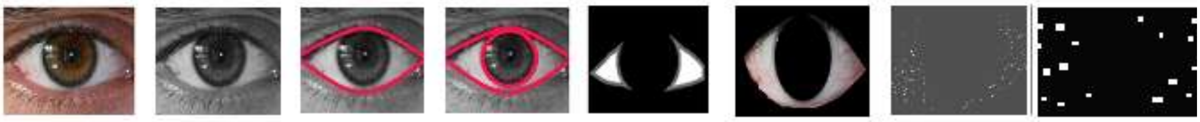


Fig.3: Human eye pattern

Finally, line descriptor based feature extraction method is used to describe and store the extracted vein pattern for recognition, registration, and matching method that is scale, orientation, and deformation-invariant, and can mitigate the multi-layered deformation effects and tolerate segmentation error. The feature matching system uses an enrolment system to register the sclera vein templates [6] to achieve translation, rotation, and scaling-invariance. Then, cross-correlation distance measure is used to match the templates using their line descriptor sets. Finally, the matching score is determined from the weighted matching scores, and is used to determine if the two descriptors match.



(a) (b) (c) (d) (e) (f) (g) (h)

Fig.4: (a) Input eye image (b) Grayscale image (c) Eyelid detection (d) Iris boundary detection (e) Sclera mask (f) Segmented Sclera (g) Vessel pattern- after morphological operation (h) Extracted minutiae

III. EXTRACTION OF FINGER VEIN

Nearly all veins in a human body (such as retinal vein, facial vein, veins in hand) can be used for personal identification, but veins in hand are always preferred. To obtain the pattern for the database record, an individual inserts a finger into an attester terminal containing a near-infrared LED light as shown in Fig.5 or a monochrome CCD (charge-coupled device) camera. The haemoglobin in the blood absorbs near-infrared LED light, which makes the vein system appear as a dark pattern of lines. The camera records the image and the raw data is digitized, certified and sent to a database of registered images. For authentication purposes, the finger is scanned as before and the data is sent to the database of registered images for comparison. The authentication process takes less than two seconds.

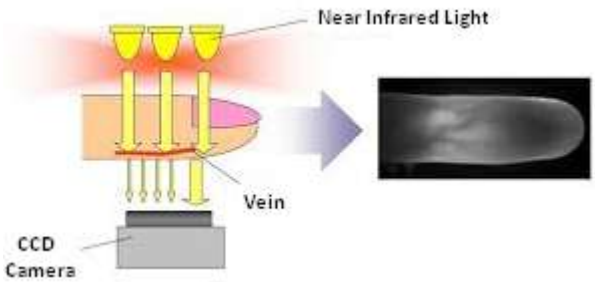


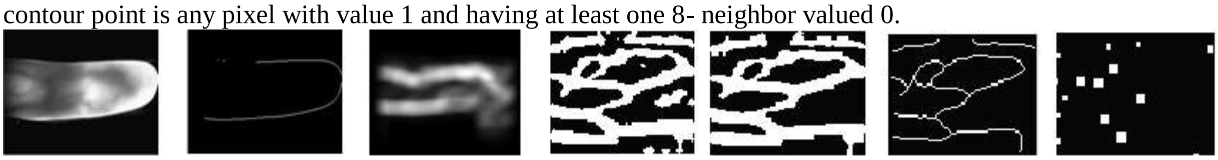
Fig.5: Fingervein system

Biometric systems based on fingerprints can be fooled with a dummy finger fitted with a copied fingerprint; voice and facial characteristic-based systems can be fooled by recordings and high-resolution images. The finger vein ID system is much harder to fool because it can only authenticate the finger of a living person. The configurations of parallel ridges and valleys with well defined frequency and orientation in a Fingervein image provide useful information which helps in re-moving undesired noise. Therefore, a band pass filter is used to tune the corresponding frequency. Moreover, orientation can efficiently remove the undesired noise and preserve the true ridge and valley structures. Gabor filters have both frequency and orientation selective properties and have optimal joint resolution in both spatial and frequency domains. Therefore, it is appropriate to use Gabor filters as band pass filters to remove the noise and preserve true ridge/valley structures. The circular Gabor filter is an effective tool for texture analysis, and has the following general form:

Eqn 1

$$G(x,y,\theta,\mu,\sigma) = \frac{1}{2\pi\sigma^2} \exp\left\{-\frac{x^2+y^2}{2\sigma^2}\right\} \exp\{2\pi i(ux \cos\theta + uy \sin\theta)\}$$

The next step in finger vein extraction is the image segmentation where the output of Gabor filter is used and vein pattern is extracted using the method as in [12]. The conditional thinning algorithm is used to thin the image, the region points are assumed to have value 1 and back-ground points to have value 0. The method consists of successive passes of two basic steps applied to the contour points of the given region, where a contour point is any pixel with value 1 and having at least one 8- neighbor valued 0.



(a) (b) (c) (d) (e) (f) (g)

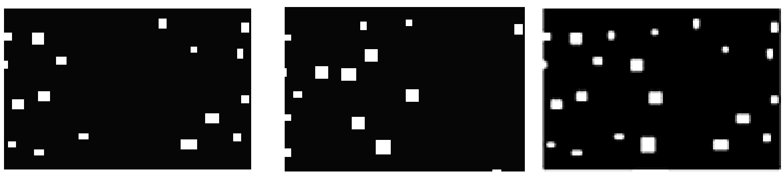
Fig.6: (a) Input finger vein image (b) Edge detected image (c) Gabor filtering (d) Image segmentation (e) Filtering (f) Thinning (g) Extracted minutiae points

The minutiae points are obtained by marking branch and end points in the vein pattern skeleton image as shown in Fig. 6. To obtain the junction points from the skeleton of vein patterns, we use pixel-wise operation commonly known as the cross number concept.

IV. FEATURE LEVEL FUSION

Feature level fusion [4] means the fusion of feature vectors obtained from several feature sources. There are several feature sources: (i) feature vectors obtained from different sensors based on a single biometric, (ii) feature vectors obtained from different entities based on a single biometric, like iris feature vectors obtained from left and right eyes, (iii) feature vectors obtained from multiple biometric traits. Feature vectors which are compatible can be combined to form high-dimensional feature vectors when several feature vectors belong to different types.

For example, Ross and Govindarajan [9] fused face features with hand geometry features, Kumar [10] proposed fusion of hand geometry features and palmprint features, X. Zhou and B. Bhanu [11] proposed feature fusion of face and gait. They trained the reconstructed faces with high resolution and gait energy images by PCA and MDA respectively in order to get feature vectors, then combined them to a fusing vector after normalization. But it is difficult to consolidate information at feature level because feature sets from different biometric modalities may neither be accessible nor compatible. The minutiae points obtained from sclera [5] and fingerprint are fused using the feature level fusion technique. A new template is generated after the fusion of the features as shown in Fig.7.



(a) (b) (c)

Fig.7: Minutiae points of (a) Sclera (b) Fingervein and (c) Fused template

V. IMPLEMENTATION

Experiments have been conducted to demonstrate the performance of the proposed method for object recognition. The finger vein database comprises of 50 trained distinct images, each image are subject to variations such as lighting. Fingervein images are taken against dark homogeneous background for both left and right hand. The images are 256 grey levels per pixel and normalized. These images are pre-processed by our method before matching experiment.

The publicly available databases are used in the experiments. The image quality in this database varies due to illumination, sharpness and other factors. The images are 800*600 color images. The algorithm in this proposed method are implemented using MATLAB (version 2011a) on a PC with Intel Core2 CPU, 1.86GHz processor,1GB RAM. The proposed authentication system can be used for large population where users can transfer huge amount in any form i.e., either through ATM or online banking as shown in Fig.7. If the matching is successful, the user will be authenticated. The flow process of multimodal biometric system is shown in Fig.8.

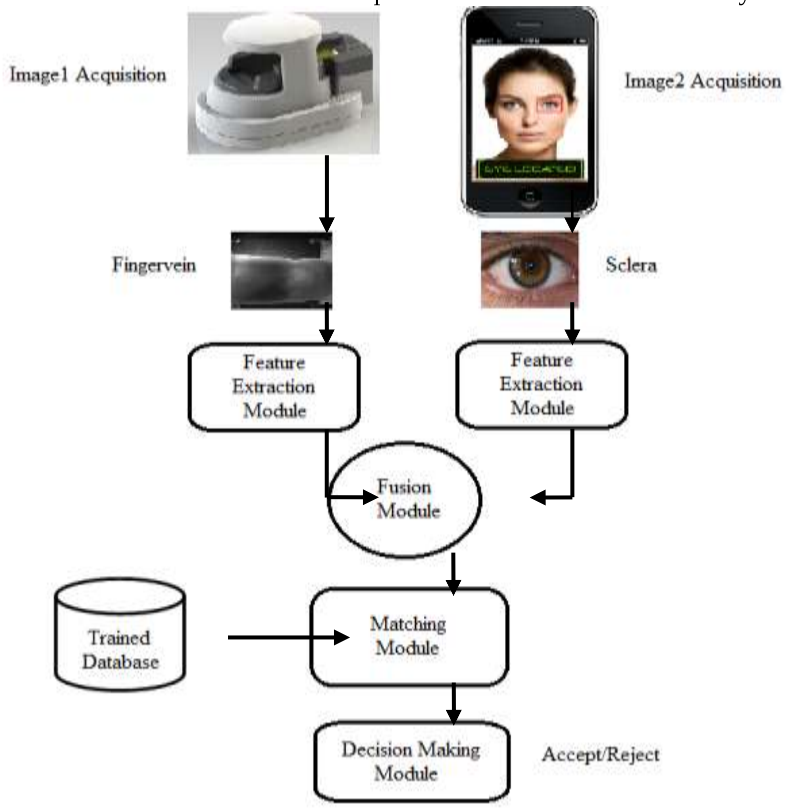


Fig.8: Flowchart of proposed Multibiometric Authentication System

VI. RESULTS

The metrics used for evaluation are False Acceptance rate (FAR) and False Rejection Rate (FRR). The FRR is the frequency that an authorized person is rejected access. The evaluation of sclera recognition was carried out with 100 images taken from UBIRIS, IUPUI and SDUMLA-HMT database were grouped into ten users and the results are tabulated for FAR and FRR. Table I and Fig.9 shows the resulted (FRR) as obtained from Eqn 2 for the proposed sclera vein and existing iris technique. From the result, it can be observed that the proposed technique results in lesser False Rejection Rate when compared to the existing techniques.

$$FRR\,(n) = \frac{Number\ of\ rejected\ verification\ attempts\ for\ a\ qualified\ person\ n}{Number\ of\ all\ verification\ attempts\ for\ a\ qualified\ person\ n}$$ Eqn 2

$$FRR = \frac{1}{N}\sum_{n=1}^{n} \mathrm{FRR}\ (\mathrm{n})$$

The FAR is the frequency that a non-authorized person is accepted as authorized.

$$FAR\,(n) = \frac{Number\ of\ successful\ independent\ fraud\ attempts\ against\ a\ person\ n}{Number\ of\ all\ independent\ fraud\ attempts\ against\ a\ person\ n}$$

$$\mathrm{FAR} = \frac{1}{N}\sum_{n=1}^{n} \mathrm{FAR}(\mathrm{n})$$ Eqn 3

The Genuine Acceptance Rate(GAR) or True Accept Rate(TAR) is defined as the fraction of genuine scores that exceed the threshold η.

$$\mathrm{GAR}\ (\eta) = 1 - \mathrm{FRR}\ (\eta)$$ Eqn 4

Table I:
FRR (%) for various users

No. of Users	Existing Fingerprint + Iris	Proposed Eye vein + Fingervein
1-10	88.5	83.6
11-20	87.7	84.3
21-30	89.3	84.7
31-40	88.1	83.9
41-50	88.3	85.2
51-60	88.9	84.8
61-70	88.4	85.3
71-80	89.6	85.4
81-90	88.7	84.8
91-100	88.8	84.5

Table II:
FAR (%) for various users

No. of Users	Existing Fingerprint + Iris	Proposed Eye vein + Fingervein
1-10	0.32	0.16
11-20	0.36	0.12
21-30	0.35	0.14
31-40	0.33	0.17
41-50	0.34	0.09
51-60	0.31	0.12
61-70	0.38	0.15
71-80	0.39	0.14
81-90	0.37	0.11
91-100	0.36	0.13

Table II and Fig. 10 shows the resulted False Acceptance Rate (FAR) for the proposed and existing technique which is obtained using Eqn 3. From the result, it can be observed that the proposed technique results in lesser False Acceptance Rate for all the persons, whereas the existing techniques results with higher percentage of False Acceptance Rate. From all the results obtained, it can be said that the proposed technique results in better security than the existing technique.

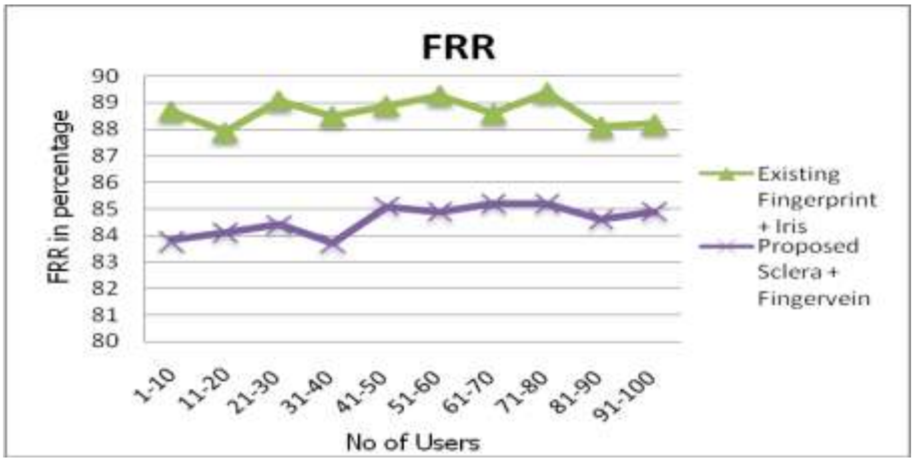


Fig.9: Resulted False Rejection rate

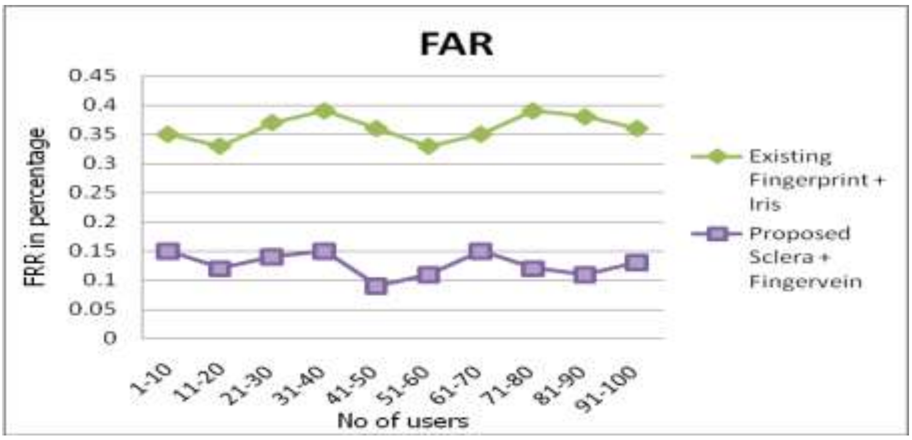


Fig.10: Resulted False Acceptance rate

VII. CONCLUSION

In this paper we have presented a secured multimodal biometric system by fusing eye vein and Fingervein images. In this system of fusion, we have considered the intersection of minutiae points of eye vein and finger vein as both are important factor for verification. There are a variety of factors taken into consideration in our biometric system, such as the number of intersections in the vein pattern, and the pattern around the intersection point. This intersection spot will be taken by the system itself, taking the intersecting point as the mid-point. We conclude that, fusion by means of this new method will ensure high level of security.

The proposed model has improved the security of the system as verified using FAR and FRR curves. Automatic authentication is possible with state of art technologies like sclera recognition on the move and finger vein scanner on the steering of car. As future improvements the cryptographic key of multimodal biometrics like sclera and iris can be developed and issued for enhancing security.

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