

*Full Length Research Paper*

# Multimodal face and finger veins biometric authentication

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**Due to the increase in security requirements, biometric systems have been commonly utilized in many recognition applications. Multimodal has great demands to overcome the issue involved in single trait system and it has become one of the most important research areas of pattern recognition. We present multimodal face and finger veins biometric verification system to improve the performance. We presented multilevel score fusion of face and finger veins to provide better accuracy. Simulation results shows that proposed multimodal recognition system is very efficient to reduce the false rejection rate.**

**Key words:** Multimodal biometric system, face, finger veins, CSLDA, Fuzzy fusion.

## INTRODUCTION

Biometric is the field of pattern recognition research that recognizes the human identity based on physical patterns or behavioral patterns of human. The physical patterns are face, finger veins, palm etc. whereas, behavioral are voice, signature, walking style etc. Biometric system using single traits, has several limitation, that is, noise during sensing, non-universality, inter-class similarities, intra-class variations, spoof attach and distinctiveness etc. thus single biometric system may leads to false acceptance rate (FAR) and false rejection rate (FRR) (Ross and Jain, 2009). Multimodal modal biometrics has become one of the intensive field of research and consequently, number of recognition approaches and combination of trait has been proposed. Multimodal biometric is the combination of multi biometrics in one system to increase the performance and robustness against the environment variations and imposter attack, in order to overcome the limitation involved in uni-modal biometric system. However, combining the multi biometrics is not a 100% guarantee that the better solution will be provided. Commonly, the multimodal biometrics are; face and finger print, face and iris, iris and finger print etc. Performance measurement of biometrics system is the most important part, and four parameters

are used to measure the performance, that is, FRR (False Rejection Ratio) which is the ratio of genuine, has been recognize as an impostor, FAR (False Acceptance Ratio) the ratio of impostor has been recognize as genuine, EER (Equal Error Rate) which is FAR and FRR are equal (the less EER is the better system performance) and ROC (Receiver Operating Characteristic) is the plot of FRR versus FAR (Prasad et al., 2009). Uniqueness and reliability of features are the two important factor that have effect on FAR and FRR.

## Related work

Beginning from late 90's, the research on multimodal started, and different multimodal biometrics has been developed with combination of various trait, that is, face and finger print, face and iris, iris and finger print etc. The most commonly used biometrics is face, that is, either as a single trait or combined with other trait as multimodal biometrics. Face combined with other biometrics at different level of fusion, that is, feature, score and decision (Ross and Jain, 2003). Chandran et al. (2009) presented iris and finger print multimodal biometrics to improve the performance. They presented multimodal biometrics using two lip texture, lip motion and audio and they performed the fusion by reliability weighting summation. Brunelli and Falavigna (2005) presented

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multimodal face and voice for identification. Kumar et al. (2007) presented multimodal personal verification system using hand images by combining hand geometry and palm image. Directional convolution masks are used to extract the palm features from normalized palm image, whereas, finger length and width is extracted for hand geometry palm and finally, different level of fusion is performed

Chin et al. (2009) integrate palm print and fingerprint at feature level. Series of preprocessing steps are applied on palm and finger print to increase efficiency and for feature extraction of 2D. Gabor filter is used and fusion is performed at feature level. Shahin et al. (2008) used three trait, that is, hand veins, hand geometry and fingerprint to provide high security by calculating the ridges, and the direction is calculated in frequency domain. Yao et al. (2007) performed feature level fusion on palm print and face for single sample, and features are extracted using PCA over Gabor filter. Zhou et al. (2007) presented multimodal authentication system using face and fingerprint, and multi route detection is used by using SVM fusion, whereas, the face image with zero turning is used as face template and other face images are used for self learning. Tayal et al. (2009) presented multimodal iris and speech authentication system using decision theory. Iris and speech biometrics are combined using energy compaction and time frequency resolution. Chu et al. (2007) presented multimodal biometrics using face and palm at score level fusion. Poinot et al. (2009) presented palm and face multimodal biometrics for small sample size problems and Gabor filter is used for feature extraction of both palm and face images.

Veins recognition utilized the vascular patterns, visible with infrared light illumination inside the human body, that is, hand, finger etc. Thus finger veins identification is difficult to falsify. Yang et al. (2009) presented finger veins recognition by using the feature combination extracted through circular Gabor filter and the feature are exploited on structural, topological and local moments. The segmentation of finger veins was based on multichannel and even the symmetric Gabor filter in spatial domain used eight orientation filters to exploit veins. Information in finger and finger veins image is segmented using threshold.

Kang and Park (2009) presented multimodal finger veins recognition using score level fusing for finger geometry and finger veins. Based on SVM and minutiae point of finger veins, geometric features with sequential deviation are utilized for finger veins and geometry identification, respectively. Lee et al. (2009) presented finger veins recognition using minutia-based alignment and local binary pattern based on feature extraction. They also presented manifold learning and point manifold distance for finger veins recognition and ONPP is used for manifold recognition.

We presented multimodal biometrics using the multi-level score fusion of CSLDA based face recognition and statistical and topological based finger veins recognition.

## PROPOSED MULTIMODAL

We combined the face and finger veins and multilevel fusion is performed to increase the robustness of the authentication system. Actually, the authentication method is based on one to one matching, whereas, the recognition methods is based on one to many match. The score level fusion within CSLDA for face recognition and fusion of fused face result and finger veins result is performed. Figure 1 present the multimodal recognition system. The presented approach is divided into two parts: Face authentication and fusion Finger veins authentication, and fusion with fused face result at first level.

The preferment of the Face recognition is as a result of the use of client specific linear discriminant analysis, and the results for genuine and imposter are fused (Rowshan et al., 2008) as shown in Figure 1. The PCA and LDA based approaches are based on global representation of testing and training data in feature space while client specific liner discriminant analysis (CSLDA) is a conventional LDA representation that involved multiple shared faces. Instead of multiple shared fisher face among all clients, CLSDA uses the PCA and LDA to generate a client specific template for each user (Kittler et al., 2000).

As only one fisher face is involved in authentication, thus it is speedier than LDA and PCA. The authentication is based on comparison of claimed user's features with face images features. The claim user is either accepted or rejected based on the minimum Euclidean distance computed. The decision is based on the combined score of distance, client and distance and imposter mean. It can be either tested against the client mean or can be tested against the imposter mean:

$$\begin{aligned} d_c &= |a_i z - a_i \mu_i| \\ d_c &\leq t_c && \text{Claim } \textit{accept} \\ d_c &\geq t_c && \text{Claim } \textit{reject} \end{aligned} \quad (1)$$

For finger veins, we used the Gabor filter to enhance the finger vein image and then thinning operation is performed to obtain the skeleton for feature extraction. We extracted topological structural and statistics features from thinned finger vein image. The statistical prosperities of finger vein represent the curves connection with the cross point.

The angle features can better describe the invariant property, that is, scale, rotation etc. The feature that describe the connection information contain less discrimination, thus the angle related to cross points are extracted and for recognition purpose, we used the nearest cosine classifier (Yang et al., 2008):

$$W = \sum_{j=1}^m S_j \quad (2)$$

$$S_F = \sum_{j=1}^m S_j \quad (3)$$

$S_i$  is the  $i$ -th normalized score

$$S_{FF} = \sum_{j=1}^m ((1 - W) S_{FV}) + W S_F \quad (4)$$

The Fuzzy fusion is performed on the two results and shown in Figure 2, whereas, for fusion of face and finger veins, we performed weighted Fuzzy fusion on the fused result of face and finger veins.

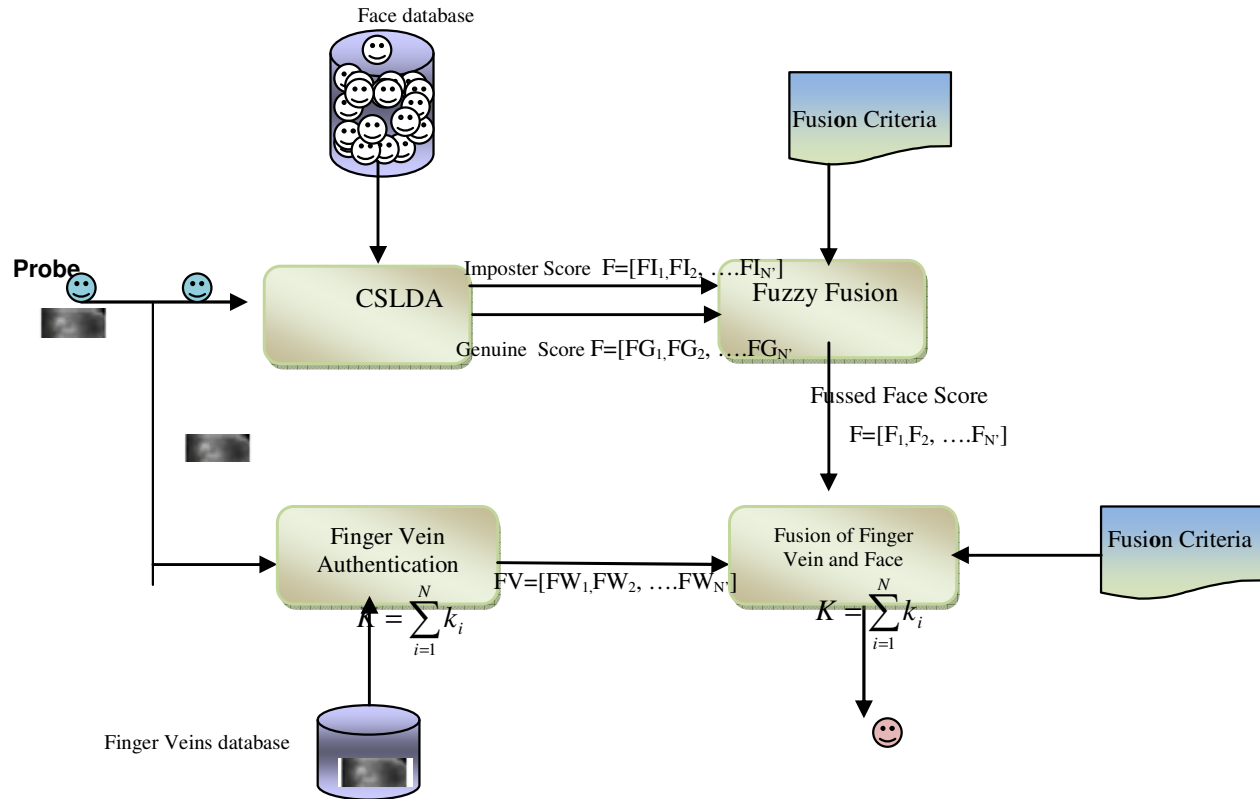


Figure 1. Multimodal face and finger veins recognition.

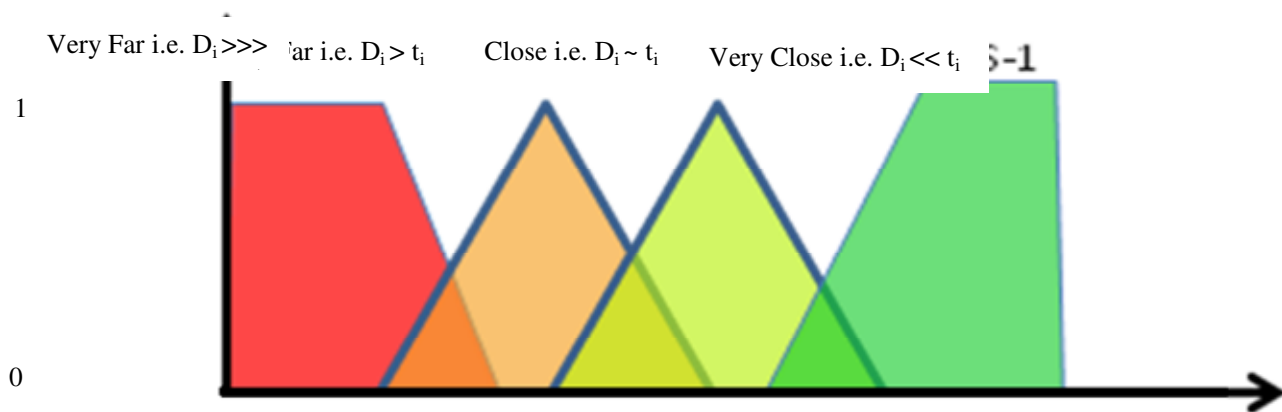


Figure 2. Fuzzy classification model for face.

**Algorithm: Recognition based authentication**

Input: A set of N training classes face and finger veins, each class contain 6 face images and 3 finger veins, and probe P face and finger vein image for testing.  
 Output: Identified User.

**Algorithm**

- Step 1: Perform CSLDA based authentication on N client for probe P.
- Step 2: Calculate the Genuine and imposter weight for probe P.

Step 3: Perform Fuzzy fusion on imposter and genuine results using the Equation 4

FI and face FG result.

Step 4: Perform Finger veins authentication for probe p.

Step 5: Fuse the finger veins results, face result  $FV = [FW1, FW2, \dots, FWN]$  and F using weighted fuzzy fusion as shown in the equations and tables when scores of multimodal biometrics are consolidated to reach final recognition result, it is referred to as the 'score level fusion'. We performed score level fusion on the face and finger veins score using rules R-I and R-II. In other words, if the client in sub dataset results of both face and finger veins are true, then it is accepted, hence it is considered as imposter.

**Table 1.** Fuzzy influence rule for face recognition.

Distance/Position	Very close	Close	Far	Very far
Very close	Fail	Risky-L1	Pass	Pass
Close	Risky-L1	Risky-L1	Pass	Pass
Far	Fail	Risky-L2	Risky-L1	Pass
Very Far	Risky-L2	Fail	Fail	Fail

**Table 2.** Linguistic labels used for multimodal biometrics.

Abbreviation	Description
Pass	Accepted as genuine
Risky-L1	Risk Level1 and weigh assign to face $W = 0.3-0.4$
Risky-L2	Risk level 2: More chance of imposter $W = 0.15-0.3$
Fail	Rejected by considering imposter

**Table 3.** Fuzzy inference rule for Face and finger veins recognition.

Distance/Position	Accept	Risk Level-1	Risk Level-2	Reject
Very close	Pass	Pass	Pass	Fail
Close	Pass	Pass	Risk	Fail
Far	Risk	Fail	Fail	Fail
Very far	Fail	Fail	Fail	Fail

Secondly, if there is very close tie of face recognition between two clients, then finger veins contribution is more in the final decision. Although in this case both results are not true, but the final results is approximated by considering the next close results of face discussed in case-III.

## EXPERIEMENT RESULTS AND DISCUSSION

For the purpose of this experiment, we used low resolution web camera for face images. The face and finger veins data is obtained on 35 voluntary CAIRO staff and students. For face training, six images of each user were taken, and for finger veins we extracted three images of first finger in controlled environment. Using the eye point, face is extracted and normalized to  $60 \times 60$ . We found a considerable performance in term of FAR to 0.05 and GAR to 92.4 using the multilevel fusion of class specific to client specific of face recognition and finger veins of selected clients.

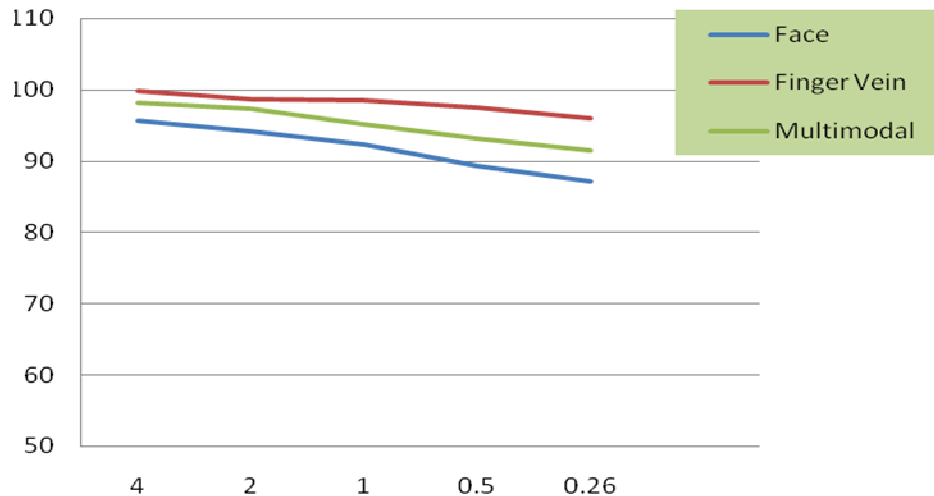
First fusion of imposter result and genuine result were performed for face, based on client specific linear discriminate analysis and finger veins recognition is performed using statistical and topological features. Finally, finger veins and face authentication was performed on each selected client. We presented three cases that described the performance proposed as compared to conventional approaches. For testing purpose, we performed two tests on trained and untrained person. For each person we

took two face and two finger veins images. The system authenticates the person against the provided ID. Tables 1, 2 and 3 are used for Fuzzy linguistic variables calculation.

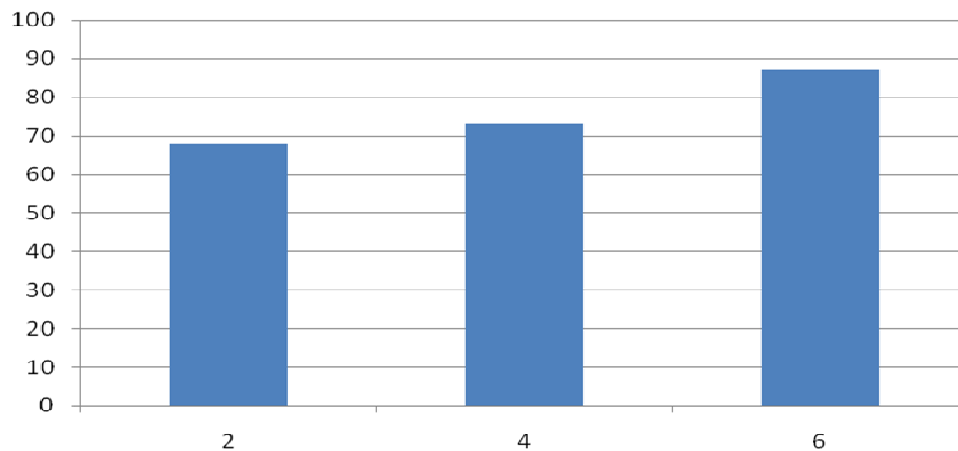
Figure 3 describes the FAR and GAR. There is prominent improvement by fusing the finger veins and face recognition based on the selection of few faces from large data set, based on 3 images for finger veins and 6 images for face. Figure 4 presents the face recognition results, FAR and GAR, respectively using 2, 4 and 6 training samples. Based on this experiment, it was suggested that recognition based on authentication by fusing the finger veins and face, performs better than conventional recognition technique.

## Conclusion

We presented multimodal face and finger veins recognition systems in which multilevel score level fusion was performed. Since there is no database for finger veins and face, thus we test the CAIRO employer and students. The imposter and genuine score are combined using Fuzzy fusion to increase the face recognition system. Simulation results shows that proposed multimodal recognition system is very efficient in reducing the FAR 0.05 and increasing GAR 91.4. The GAR and FAR can further be optimized by applying class to client approach



**Figure 3.** Recognition result using Multimodal Biometrics.



**Figure 4.** Face recognition based on authentication mechanism.

on finger veins.

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