All Sciences Proceedings
1st International Conference on Pioneer and Innovative Studies
June 5-7, 2023 : Konya, Turkey
ICPIS
All Sciences Proceedings
http://as-proceeding.com/

https://as-proceeding.com/index.php/icpis

Enhancing Person Identification with Score Fusion of Biometric Modalities

Kenza Chenni *, Naceur-Eddine Boukezzoula [2]

[1]*Department of electronics/LIS Laboratory, University of Ferhat Abbes Setif1, Algeria*
[2]*Department of electronics/LIS Laboratory, University of Ferhat Abbes Setif1, Algeria*

*kenza.chenni06@gmail.com

Abstract – Biometric systems play a vital role in identifying individuals by capitalizing on their distinctive physical or behavioral traits. However, individual biometric techniques have limitations that can impact the accuracy and reliability of identification. Multimodal biometric systems, which incorporate data from several modalities, have evolved as a solution to these problems. There are four levels of integration into multimodal biometric systems, but score-level fusion is seen as the most efficient. The fusion level used in this paper was the score level. The fusion proposal was assessed using the ORL Face and IITD Iris datasets. The suggested technique can enhance the ability to identify people in various areas.

Keywords – Biometrics, Multimodal Biometric Systems, Score-Level Fusion, ORL Face, And IITD Iris.

I. INTRODUCTION

In this present age world, it is essential to use trustworthy techniques for user authentication about not only the safety fears but also the quick expansions in communication, networking, and mobility [1]. Traditional authentication systems (passwords, account numbers, badges, keys, etc.) are less reliable because they are easily replaced by impersonation once they are stolen [2]. Biometrics is an emerging security technology and one of the most promising technologies of our time. Compared to traditional identification, biometrics has many advantages, such as that the technology is not lost, stolen or copied. Biometrics basically refers to a technology that authenticates identity through measurable physical or behavioral biometrics [3]. The general classification of biometric modalities is illustrated in Fig. 1. Essentially, individual biometric characteristics are divided into two primary categories: physiological traits and behavioral traits, as shown in Fig. 1.

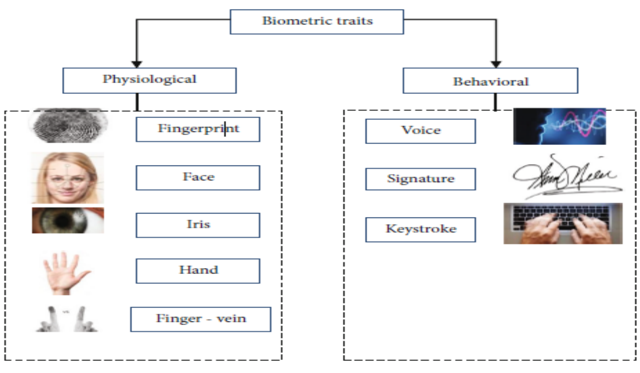

Fig. 1 Classification of biometric traits [4]

Single biometric systems have limitations like uniqueness, a high spoofing rate, susceptibility to fraudulent attacks, inaccuracies, non-universality, and noise. For instance, facial recognition technology is vulnerable to changes in facial expression, lighting conditions, emotional states such as sadness or happiness, and variations in ambient lighting conditions. All these limitations can be reduced or eliminated by the use of multimodal biometrics. This approach involves amalgamating data from multiple sources of biometric information to enhance accuracy and reduce susceptibility to errors or vulnerabilities. Information on multi-biometrics can be fused at four different levels [5] sensor level, characteristic level, score level, and decision level. Score-level fusion is widely acknowledged as the most commonly utilized method due to its superior performance compared to other types of fusion. In this paper, we simulate a multimodal biometric person recognition system based on score-level fusion. The proposed fusion technique is experimentally evaluated using the ORL Face -IITD Iris databases. The paper is organized as follows: Section II provides an overview of the database employed for validating and implementing the fusion method. Section III presents the simulation results and discussions regarding the proposed fusion approach. Finally, Section IV concludes the paper.

II. THE PROPOSED MULTIMODAL BIOMETRIC SYSTEM

Generally, face recognition and iris recognition have been considered as one of the most attractive areas for biometric schemes in the past few years. Face and iris biometrics are considered in this study.

A. *The multi-biometric system: face-iris*

The system includes the use of public biometric databases (e.g., ORL for faces, IITD for irises).

B. *The ORL Database of Faces*

The ORL Database of Faces contains 400 images from 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling), and facial details (glasses / no glasses). All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement). The size of each image is 92 * 112 pixels, with 256 gray levels per pixel [6].

.

Fig. 2 ORL database

C. *IITD Iris Database*

The IIT Delhi Iris Database mainly consists of the iris images collected from the students and staff at IIT Delhi, New Delhi, India. This database has been acquired in Biometrics Research Laboratory during Jan - July 2007 (still in progress) using JIRIS, JPC1000, digital CMOS camera [7]. The image acquisition program was written to acquire and save these images in bitmap format and is also freely available on request. The currently available database is from 224 users, all the images are in bitmap (*.bmp) format. All the subjects in the database are in the age group 14-55 years comprising of 176 males and 48 females. The database of 1120 images are organized into 224 different folders each associated with the integer identification/number. The resolution of these images is 320 * 240 pixels and all these images were acquired in the indoor environment [8].

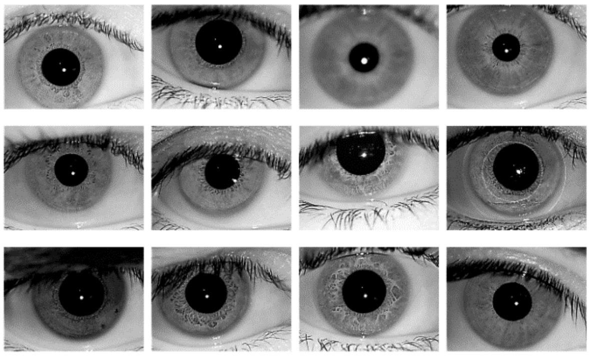

Fig. 3 IITD Iris database [8]

III. EXPERIMENTAL RESULTS AND DISCUSSION

A. *EXPERIENCES*

In our experiment, we used two widely used databases, ORL-Face and IITD-IRIS, to demonstrate the effectiveness of score fusion in enhancing person identification accuracy.

B. *Score-level fusion using the ORL- face and IITD -IRIS database*

We designed a flowchart covering the different steps of our score fusion system (Fig.1).

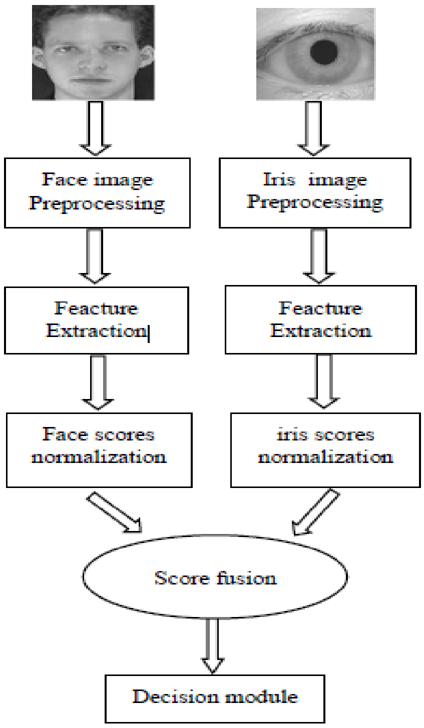

Fig. 4 Diagram of the score fusing process

The scores of two systems (the ORL Face database and the IITD Iris database) are normalized in the domain [0, 1] before they are combined. The normalized scores are merged by different merging methods to make the final decision (customer or impostor).

C. *The experimental protocol*

We conducted experiments on the ORL Face and IITD Iris databases to evaluate the effectiveness of score fusion methods. To assess the performance of these methods, we established an experimental protocol and utilized several performance metrics, including Genuine Acceptance Rate (GAR), and False Acceptance Rate (FAR), and equal error rate (EER). To analyse the performance of the score fusion system, we plotted a Receiver Operating Characteristics (ROC) curve that displays the relationship between GAR and FAR, where GAR = 100-FRR. GAR represents the acceptance rate of genuine users, FAR indicates the rate of impostors accepted as genuine, and FRR is the rate of genuine users rejected as imposters. We evaluated the system's ability to correctly identify genuine users based on GAR.

We used four images per user. 2 images for the train and 2 images for the test, belonging to 40 people, were selected from each database: we have 80 or (40× 2) Actual scores and 3120 (40 ×39×2) Impostor scores.

D. *Simulation results and discussion*

The development of a multimodal biometric (face and iris) system is one of the most significant steps in this study. In this part, we will see the different results that correspond to the different score fusion methods (preceded by a normalization phase).

The performances of the score fusion methods on the IITD Iris and ORL Face databases are presented by the ROC curves. The ROC curve is used to visualize and compare the performance of individual modalities (unimodal systems) and merged modalities (multimodal systems) obtained by score fusion methods. For a value of FAR equal 0.1%, the GAR of the face and the iris are respectively 82% and 83.75%. GAR values for melting methods are also taken at the FAR point of 0.1%.

E. *Results*

In this part, we present the different results of EER and separation distance and the experimental results of the different proposed methods of fusion at the level of scores.

- **EER for performance evaluation**

The equal error rate (EER) results for single systems (face, iris) and multimodal systems obtained by score fusion using usual methods are documented in Table 1.

Table 1. EER of unimodal systems (ORL Face and IITD Iris) and multimodal systems obtained by score fusion using usual methods

Biometric system	**EER (%)**
Uni-modal systems	
Face	8.15
Iris	8.75
Multimodal systems	
Min	5.46
Max	5.00
Prod	2.37
Mean	1.25

From these results, we note that the rate of EER for single-modal systems (face and iris) is 8.15% and 8.75%, respectively, while the rate of EER for the" Mean rule" method is 1.25%. It is clear from these results that the" Mean - rule" method gives better performance when compared with the monomodal systems and makes it possible to significantly improve the system's performance.

- **Separation distance for performance evaluation**

The different distance values of the unimodal system (face and iris) and multimodal system obtained by score fusion using the usual methods (min, max, prod, mean) are presented in Table 2.

Table 2. The value of (d') of unimodal systems and multimodal systems obtained by score fusion using usual methods.

Biometric system	(d')
Uni-modal systems	
Face	2.86
Iris	3.11
Multimodal systems	
Min	3.08
Max	4.22
Prod	3.70
Mean	4.45

Based on the results, the "mean rule" method has reached a greater distance value compared to the unimodal system (face/iris).

Figures 5 and 6 represent the score distribution curves for each modality (face and iris), and figure 7 represents the score distribution of multimodal systems obtained by score fusion using the "Mean rule" method.

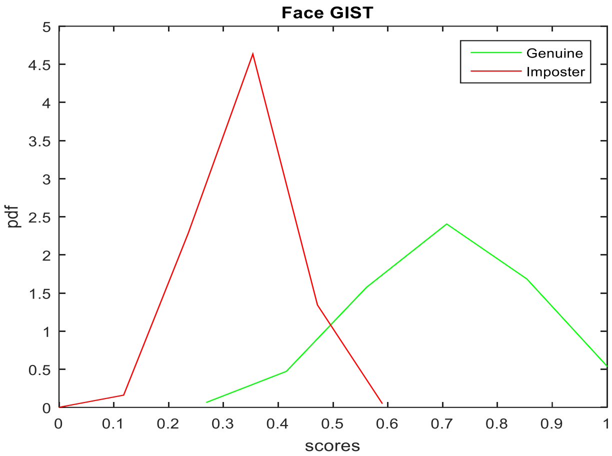

Fig. 5 score distribution of " face"

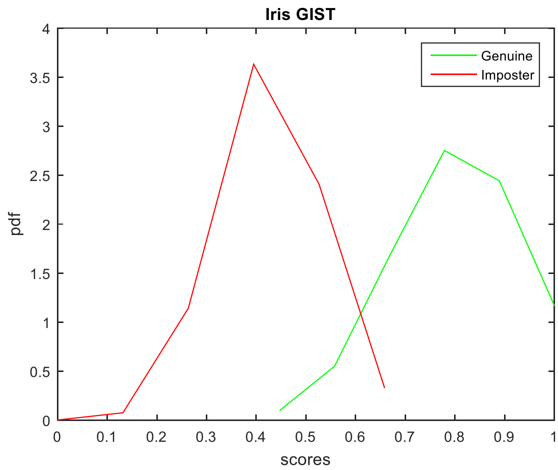

Fig.6 Score distribution of" iris "

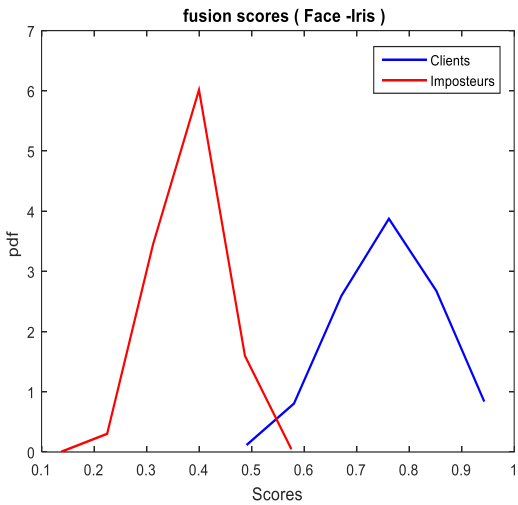

Fig.7 score distribution of multimodal systems obtained by score fusion using "Mean rule "

Figures 5, 6, and 7 show the probability density functions (pdf) of unimodal and multibiometric systems. For unimodal systems, there is an overlap between the distributions of genuine and imposter scores. For better recognition, this overlap should be as minimal as possible. Thus, if we see Figure 7, where both unimodal systems are fused via the "mean rule" method, the overlap was low and there was a greater distance value (d') (the greater the distance between customers and scammers, the less likely interference will occur), thus ensuring better recognition.

- **Fusion scores using the proposed methods**

In this part, we test the proposed methods of score fusion on the ORL Face and IITD Iris databases. Let, x: the scores derived from IITD Iris, and y: the scores derived from an ORL face, and t (x, y): the merging of two scores using methods of proposed score fusion.

Table 3. Experimental results of the different proposed methods of merging at the level of scores

Methods	**Functions**	**GAR %**
Method 1	$t(x,y) = \frac{x + y + 2 * x * y}{2 * (x + y)}$	**95.3**
Method 2	$t(x,y) = x^{0.5} + y^{0.5}$	**94.90**

Figures 8 and 9 present the ROC curves of the merged modalities obtained by merging at the score level with different proposed methods. The GAR values of the proposed methods of merging scores, Method 1 and Method 2, reach the values 95.3 and 94.9, respectively.

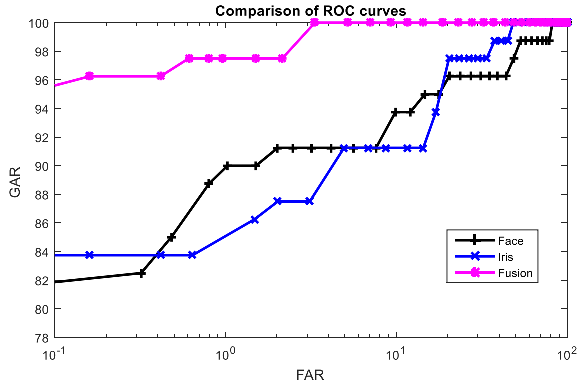

Fig.8 ROC curves of fusion at score level using "meth1"

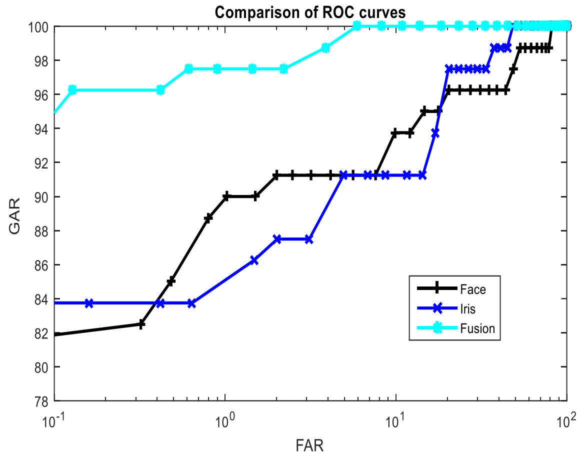

Fig.9 ROC curves of fusion at the score level using "meth2"

Figures 8 and 9 represent the difference between the monomodal and multimodal systems, with a face and iris realization rate of 82% and 83.75%, respectively, at FAR = 0.1%. While the GAR values of "Meth 1" and "Meth 2" are 95.3% and 94.9%, respectively, at FAR = 0.1%, the point fusion level system gives better results with the "Meth 1" rule because it gives a good result compared to mono-systems and thus improves the performance of identifying people.

IV. CONCLUSION

In conclusion, score fusion is a powerful technique for enhancing person identification accuracy by combining multiple biometric modalities. Our experiment using the ORL Face and IITD Iris databases demonstrated the effectiveness of score fusion in improving identification rates. As biometric identification becomes more prevalent in our daily lives, score fusion is likely to become an increasingly important tool for achieving accurate and reliable identification.

Acknowledgment

The authors offer praise to the General Directorate of Scientific Research and Technological Development of the Republic of Algeria in general and the LIS laboratories of the University of Setif in particular.

References

[1] D. Bhattacharya, R. Ranjan, F. Alisherov and C. Minkyu, “Biometric Authentication: a Review,” International Journal of u- and e- Service, Science and Technology, vol. 2, No. 3 pp. 13-27, Sep 2009.

[2] Y. Wang, D. Shi, W. Zhou, “Convolutional Neural Network Approach Based on Multimodal Biometric System with Fusion of Face and Finger Vein Features,” Sensors., vol. 22, no 16, p. 6039, 2022.

[3] K.O. Bailey, J.S. Okolica, G.L. Peterson, “User identification and authentication using multi-modal behavioral biometrics,” Comput. Secur., 43, 77–89, 2014.

[4] W. Yang, S. Wang, N. M. Sahri, N. M. Karie, M. Ahmed, and C. Valli, “Biometrics for Internet-of-Things security: a review,” Sensors., vol. 21, no. 18, p. 6163, 2021.

[5] J. Peng, A. A. Abd El-Latif, Q.Li and X. Niu, “Multimodal biometric authentication based on score level fusion of finger biometrics,” Opt. Int. J. Light Electron Opt., vol. 125, no 23, p. 6891-6897,2014.

[6] https://paperswithcode.com/dataset/orl

[7] http://www.jiristech.com/download/jpc_series.pdf

[8] https://www4.comp.polyu.edu.hk/~csajaykr/IITD/Database_Iris.htm