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People Recognition Based on Fusion at The Score Level Using NIST-Database

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***Abstract* –** The identification of individuals has become essential to ensure the security of systems and organizations. Biometrics refers to the automatic recognition of individuals based on their physiological or behavioral characteristics. However, the unimodal biometric system suffers from certain limitations, to overcome these problems and to get better performance in terms of recognition rate, information from different biometric sources is combined, and these systems are called multimodal biometric systems. Integration into multimodal biometric systems takes place at four levels and score level fusion is the most effective. In this paper, a scheme for score-level fusion has been proposed based on different methods of fusion the score (usual and proposed). Experimental results on one of the three databases accessible to the public of NIST-BSSR 1, this database data called NIST-BSSR1 Set2 (NIST-Fingerprint), The results obtained showed the superiority of the proposed approach over many of the fusion methods proposed by the researchers.

Keywords – Biometrics, Multimodal Biometric Systems, Score -Level Fusion, Methods Of Fusion Score, NIST-Fingerprint Database.

I. Introduction

Nowadays, how to accurately identify a person and protect the security of sensitive data has become an important topic for all people. Especially with the spread of information technology and the growth of means of communication. Traditional authentication systems (passwords, account numbers, badges, keys, etc.) are less reliable because they are easily replaced by impersonation once they are stolen [1]. The latest technologies in the security field known as biometrics have been used as an alternative to these traditional recognition mechanisms due to the increasing threats in identity management and security tasks [2]. Biometrics have become one of the most important tasks of interest to many researchers in information security. In access control applications, biometrics are an effective, simple and secure solution, ensuring better performance. Biometrics based on automatic technologies that can be used to recognize an individual based on their physical characteristics like fingerprint, hand geometry, face, palm print, hand vein, iris, retina or behavioral like signature, keyboard dynamics and gait, etc. There are two types of biometric recognition systems, unimodal (that uses a single biometric feature) and multimodal (that uses two or more biometric features). While single-modal systems are reliable, have contributed to a high level of confidentiality, and have proven superior to traditional methods used previously, they do have limitations [3]. These include problems with noise in the sensed data, non-universality problems, vulnerable to spoofing attacks and intra-class [4]. All these limitations can be reduced or eliminated by the use of multimodal biometrics which is based on the combination of various information from the different biometric source. Information on multi-biometrics can be can be fused at four different levels [5] sensor level, characteristic level, scores level and decision level. The score level fusion is the most common since it has been generally proven to be more effective than the rest of the fusion levels. In this paper, we simulate a multimodal biometric person recognition system based on a score-level fusion, in this context we propose an experimental evaluation of the proposed fusion based on the NIST-BSSR1 database. The remainder of the paper is structured as follows: Section II presents the description of the database used during the validation and implementation of the fusion adopted approach. Section III reviews The Simulation Results and Discussion of the proposed fusion approach. Section IV is the conclusion of the paper.

II. EXPERIENCES

In this section, we present an experimental evaluation of the proposed fusion on one of the three publicly available NIST-BSSR 1 databases.

A. *Database*

The score-level integration framework is offered to evaluate on one of the three NIST-BSSR1 data sections. This section is a NIST-BSSR1 Set2 (NIST-Fingerprint) dataset. To evaluate the performance of the multimodal system obtained by score fusion methods, we need a multimodal database with a larger number of users to obtain better results. The Set2 (NIST-Fingerprint) database consists of a large number of user scores compared to Set1 (NIST-Multimodal) and Set3 (NIST-Face). This is why we chose the NIST-Fingerprint database which was available at the LIS laboratory. In what follows, we will describe this base.

B. *The NIST database - fingerprint*

The NIST - fingerprint database contains two sets of scores obtained from the left and right index finger of the same users, the number of users here is 6000, we have 6000 authentic scores and 35,994,000 (6000*5999) impostor scores for each modality [6].

III. RESULTS AND DISCUSSION

A. *Score-level fusion using the NIST-fingerprint database*

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

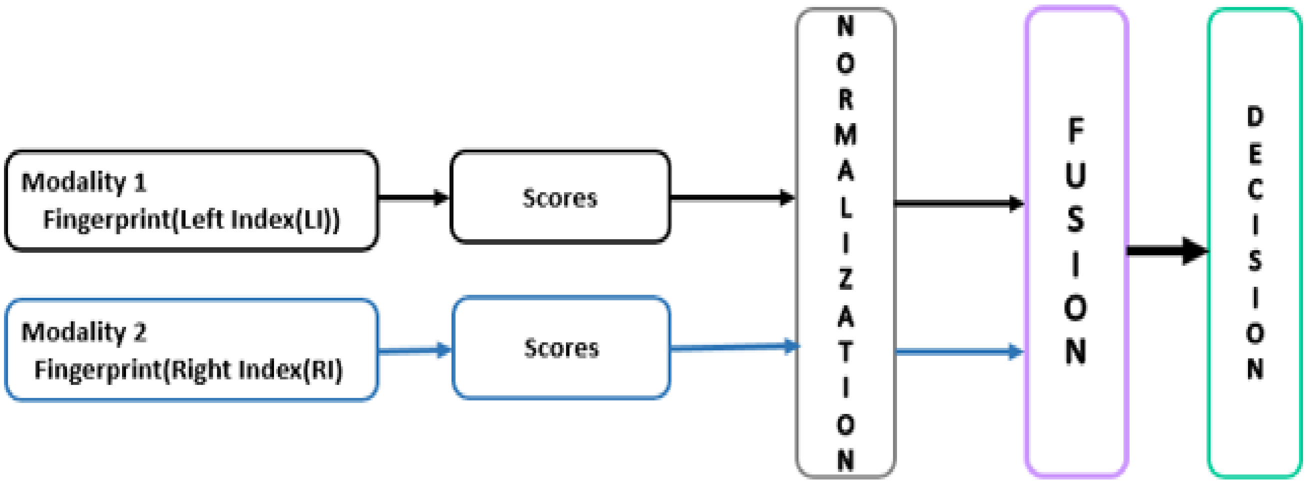

Fig. 1 Diagram of the score merging process

The NIST-fingerprint database contains two sets of scores obtained from the left and right indexes (LI, RI) of the same users. The scores of two systems (LI, RI) 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).

B. *The experimental protocol*

We tested the score fusion methods on the NIST-fingerprint database. To estimate the performance of the score fusion methods, it is necessary to define an experimental evaluation protocol of the proposed fusion. The performance metrics used in our analysis are Genuine Acceptance Rate (GAR), False Acceptance Rate (FAR). The performance of the proposed fusion system is evaluated using the ROC (Receiver Operating Characteristics) curve, which is a plot of GAR versus FAR where (GAR = 1-FRR) is the actual acceptance rate, FAR is the rate at which impostors are accepted as genuine and FRR is the rate at which genuine users are rejected as imposters, and GAR is the rate at which the right person is accepted as a genuine user.

C. *Simulation results and discussion*

In this part we will see the different results that correspond to the different score fusion methods (preceded by a normalization phase).

- Study of the performances of fusion methods at the level of scores

The performances of the score fusion methods on the NIST-Fingerprint database 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 = 0.01%, the GAR or (1-FRR) of right fingerprint and left fingerprint are respectively 83.5% and 75.5%. GAR values for melting methods are also taken at the FAR point of 0.01%.

Our score fusion work is divided into three parts:

- Part 1: fusion at the score level using usual methods

We tested the score fusion methods: Maximum, Minimum and Product on the multimodal NIST-Fingerprint database. Let, x: the scores derived from a left index fingerprint (LI), y: the scores derived from a right index fingerprint (RI), g (x, y) the fusion of two scores using methods of fusion of usual scores.

✓ The obtained results:

The results were presented by the ROC curve.

1. Maximum method (max):

$$g\ (x, y) = max(x, y) \qquad (1)$$

Figure.2 represents the ROC curve of individual modalities (LI, RI) as well as merged modalities using the usual "max" method in the NIST-Fingerprint database. At FAR = 0.01%, the GAR of the right and left indexes and of the "max" fusion method are respectively equal to 83.5%, 75.5% and 90.3%.

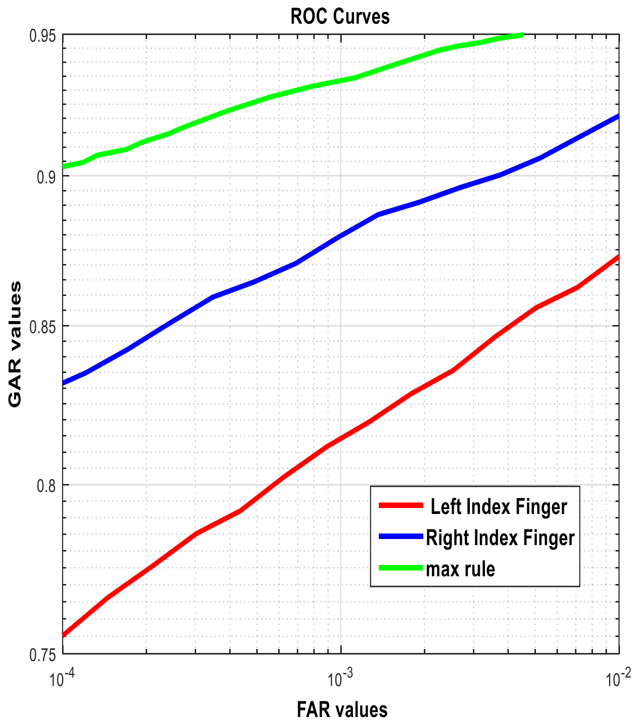

Fig. 2 Comparison of ROC curves of individual biometric modalities (LI and RI) and their fusion using the ''max'' fusion method

According to these results, we see that the merged modalities using the usual "max" method achieve better performance than the individual modalities (LI, RI). So, the "max" method is acceptable.

2. Minimum method (min):

$$g(x, y) = min(x, y) \qquad (2)$$

Figure.3 represents the ROC curve of the individual modalities (LI, RI) as well as the merged modalities using the usual "min" method in the NIST fingerprint database. At FAR = 0.01%, the GAR of the "min" method is equal to 79.6%.

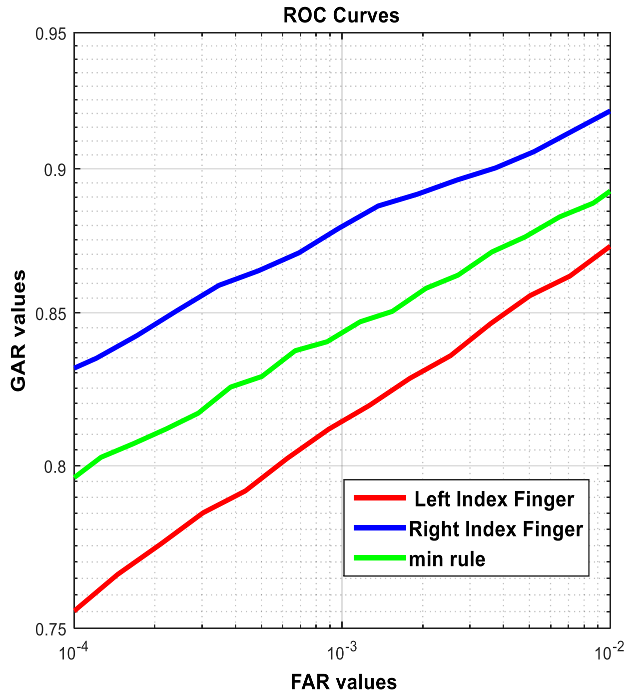

Fig. 3 Comparison of ROC curves of individual biometric modalities (LI and RI) and their merging using the "min" method.

From these results, we see that the merged modalities using the usual method "min" achieve better performance than the individual modality (LI) and inferior to the other (RI). So, the "min" method is unacceptable.

3. Product Method:

$$g(x, y) = xy \quad (3)$$

Figure. 4 represents the ROC curve of individual modalities (LI, RI) as well as merged modalities using the usual "product" method in the NIST fingerprint database. At FAR = 0.01%, the GAR of the "product" method is equal to 89%.

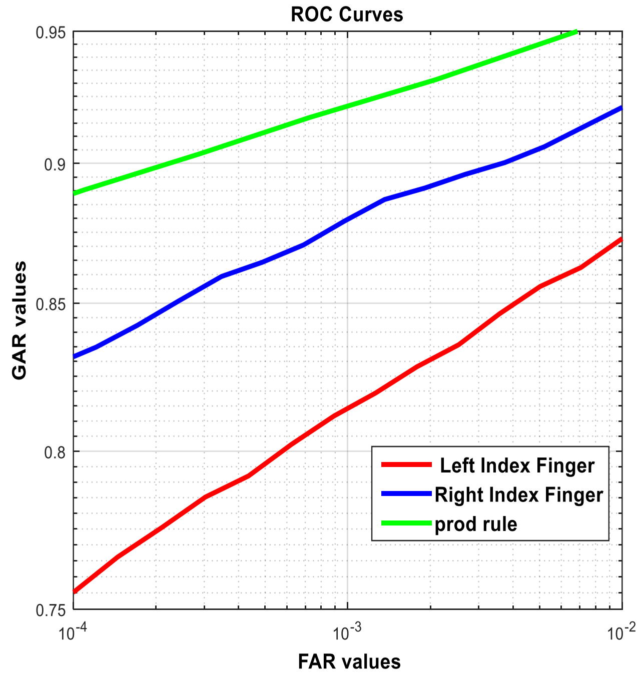

Fig.4 Comparison of ROC curves of individual biometric modalities (LI and RI) and their merging using the "prod" method

From these results, we see that the merged modalities using the usual "product" method achieve better performance than the individual modalities (LI, RI). So, the "product" method is acceptable.

Figure .5 shows the individual categories (LI, RI) and the merged categories obtained by the fusion of scores on the NIST-Fingerprint database by the max, min and product. At FAR=0.01%, the GAR for the right and left fingerprint are 83.5% and 75.5%, respectively. Whereas, the GAR values of the max, min and product score fusion methods respectively reach the values of 90.3%, 79.6%, 89%.

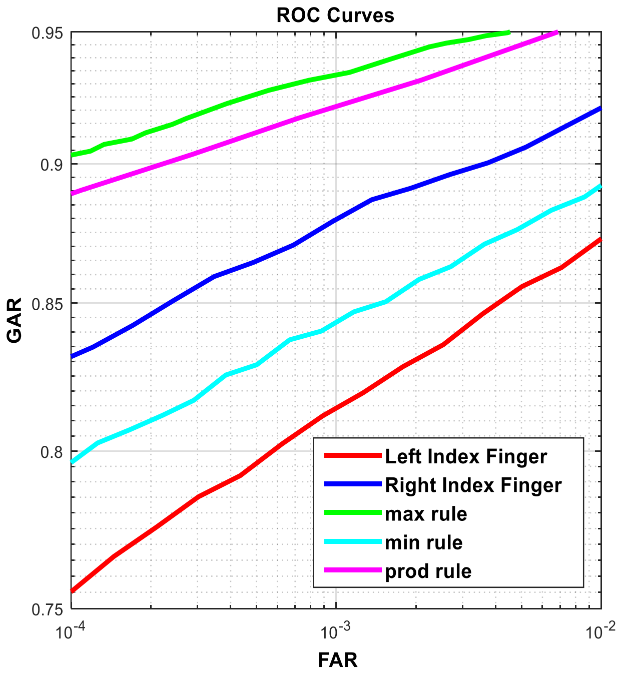

Fig. 5 ROC of individual biometric modalities (LI and RI) and their fusion using fusion methods (max, min, product)

According to these curves and the results of the various fusion methods applied on the mentioned database, we notice that the fusion at the level of scores by the max method gives the best result and makes it possible to significantly improve the performance of the system.

- Part 2: fusion scores using the proposed methods

In this part, we test the proposed methods of score fusion on the multimodal NIST-Fingerprint database. Let, x: the scores derived from a left index (LI) fingerprint, y: the scores derived from a right index (RI) fingerprint, g (x, y): the merging of two scores using methods of Proposed score fusion.

✓ The obtained results:

The results of multimodal recognition systems using proposed methods are presented by the ROC curve. The functions of the proposed methods and their GAR values are shown in the following table.

Table 1. Experimental results of the different proposed methods of merging at the level of scores

Methods	**Functions**	**GAR%**
Method 1	$g(x,y) = \frac{xy}{1-x-y+2xy}$	**89.2**
Method 2	$g(x,y) = \frac{x+y-xy}{1+x+y-2xy}$	**91.4**
Method 3	$g(x,y) = \frac{\max(x,y)}{1+x+y-2xy}$	**90.1**
Method 4	$g(x,y) = x^{1-0.8}y^{0.8}$	**87.9**

Figure. 6 presents the Roc curves of the merged modalities obtained by the merging at the score level with different proposed methods. The GAR values of the proposed methods of merging scores of the method 1, method 2, method 3 and method 4 reach the values 89.2, 91.4, 90.1 and 87.9 respectively.

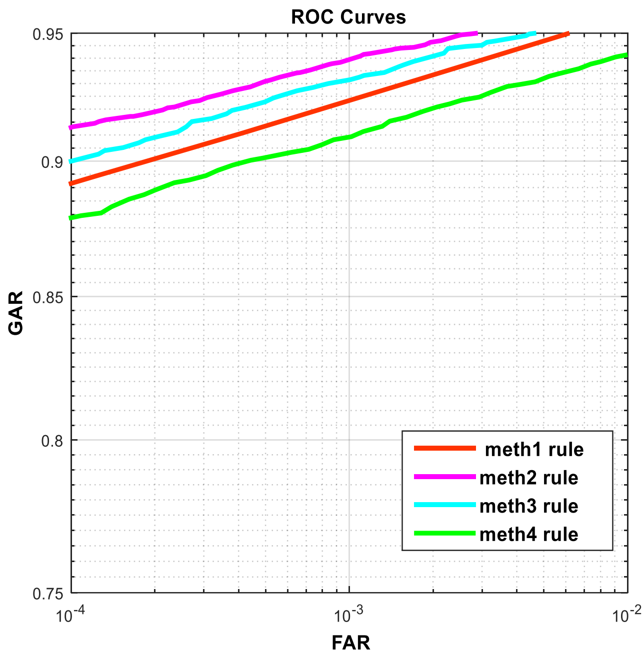

Fig. 6 ROC curves of fusion at score level

According to these curves and the results of the various proposed methods of fusion applied on the mentioned database, we notice that the fusion at the level of scores by method 2 gives the best result and makes it possible to significantly improve the performance of the system.

- Part 3: Score fusion performance comparison between our work and previous work on the NIST-Fingerprint database

In this part, we compare the performance of the score fusion of our best proposed method (Method 2) and best usual method max with the methods of previous works, and the results of each are presented in Table 2. It can be observed from the table that method 2 is very competitive and gave a better result compared to fusion methods based on WQAM using tanh function and WQAM using sin function. Moreover, we can notice that method 2 outperforms and gives a better result compared to the methods: S-sum using probabilistic t-norm, S-sum using Max rule, Frank t-norm with p = 1.3, Hammcher t- norm, Entropy-with-franc p=0.01 and Entropy-with-hamacher p=0.01.

Similarly, the "max" method also gave a better result compared to some methods in previous works.

A comparison of score fusion via different techniques on the NIST-Fingerprint database is shown in Table 2.

Table 2. Score fusion performances of different techniques

Score-level fusion method for FAR = 0.01%	**GAR (%)**
Method 2	**91.4**
Max method	**90.3**
S-sum using probabilistic t-norm [6]	89
S-sum using Max rule [6]	90.75
WQAM using function $(\cos)^r$avec r = 11 [7]	91.60
Frank *t*-norme with p = 1.3 [8]	88.04
Hammcher *t*-norme [8]	85.36
WQAM using sin function [7]	91.17
WQAM using tanh function [7]	91.29
Entropie-with-franc p=0,01 [9]	87.77
Entropie-with-hamacher p=0,01 [9]	85.42

IV. Conclusion

In this manuscript, we presented a multimodal biometric system based on a score-level fusion using different score fusion methods proposed in our work. Experimental evaluation was done using a publicly available NIST-Fingerprint database. The results of the tests carried out allow us to conclude that our system according to the methods of fusion of scores shows good performances and improves the rate of recognition of the people compared to the works having used the same database.

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