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An Overview on Multimodal Biometrics

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Abstract
Multimodal biometrics is an emerging technology which is used in various fields of security. Every human being is unique from others either by physiological or behavioral characteristics. Multimodal biometrics is more accurate and efficient than unimodal. Unimodal system takes only one physiological or behavioral characteristics of the person to make identify or verify that person. Whereas in multimodal biometrics system takes two or more traits. Multimodal avoids unauthorized access, here it possess much security than unimodal biometrics system which cannot be spoofed. In this paper various multimodal biometrics techniques were discussed, various fusion techniques with their advantages over unimodal system. Multimodal biometric system have become an unescapable trend in the future.

Index Terms- Multimodal biometrics, fusion, normalization, levels of fusion, operational modes.

Introduction

An accurate automatic personal authentication is becoming more and more important in information society [1]. Everywhere there should be a security system to access personal information to avoid theft of information. Biometric system became a robust method for authentication [2]. Biometrics technology is the emerging technology in the world. Biometric system is used for identifying and verifying individuals based on their physiological characteristics like fingerprint, face, palm print, iris, inner knuckle print and etc. or behavioral characteristics like voice, writing style, and gait. The three important criterions for choosing biometrics are universality, uniqueness and permanence. Just in America around one million individual possessed 5% of the population above 18 years old were stolen identification in 2003[3]. Biometric authentication can be used in any fields for security places like banking, government, schools and etc. biometrics system has two modals namely unimodal and multimodal. Unimodal or Monomodal uses only one trait for recognition, through this high security can't be achieved. So multimodal is introduced, they has improvement in the recognition rate and application range of system. Therefore it has inexorable tend in the future.

Though the unimodal system has some advantages it has to suffer some problems like noisy data, lack of individuality, non-universality, spoof attacks and contains a height error rates in their use [4]. Multimodal biometrics inherits multiple samples of same person in order to authenticate. So therefore multimodal biometrics system has high security which is based on multiple information of a person rather than unimodal system. This paper is organized as follows section 2 describes multimodal biometrics, section 3 describes modules of multimodal biometrics, section 3 describes fusion techniques, section 5 describes the various method of fusion levels and fusion methods, finally section 6 consists of conclusion.

Multimodal biometrics

Unimodal system confronts issues like noisy data, non-universality and interclass variation which have a tendency to build False Acceptance Rate (FAR) and false Rejection Rate (FRR), accordingly brings poor execution of the framework. To overcome some limitation we can include multiple source of information for establishing identity of person [5]. When two or more information are combined for a biometric system is referred as multimodal biometrics.

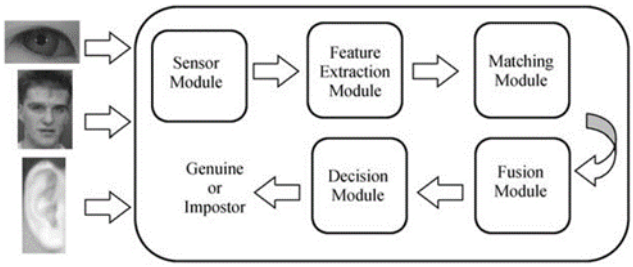

Fig.1. Block diagram of a multimodal biometrics system [7]

They address the problem of non-universality, since multiple traits ensure sufficient population coverage [6]. Multimodal biometrics recognition system replaces the existing security system which are used in places like passport, access control and banking security such as ATM (Automated Teller Machine) security. To measure the accuracy of the system Genuine Acceptance Rate, False Acceptance Rate, Equal Error Rate, and False Rejection Rate are included. The generic modal of the multimodal biometrics has two operative phases they are

A. Multimodal biometrics phases

The Multimodal biometrics consists of the following phases.

i. Enrollment phase

In this phase the trait of the individual is captured, a vector represent the biometric characteristics is extracted using a feature extraction method and stored in database as template and it is further used for authentication.

ii. Authentication phase

In this phase the trait of the individual is again captured and system uses it to either identify or verify of a person. Identify is 1: n or verify is 1:1.

Modules of multimodal biometrics

The basic biometrics system has four modules namely

A. Sensor module

This module is used to capture the trait and it's given as input for the feature extraction module

B. Feature extraction module

This module is used to extract the features after the preprocessing and these features are stored in the system database.

C. Matching module

In this module extracted feature are compared against the template (s) which is (are) stored in database.

D. Decision module

This module is used to check whether the individual is either accepted or rejected.

Fusion in multimodal biometrics system

For fusion in multimodal biometric system it has some facets such as fusion ways, fusion levels, normalization techniques and modes of operation.

A. Fusion ways

The multimodal biometrics has four modules like sensor module, feature extraction module, matching score module and decision making module. So the fusion can take place at any of these stages. The design of the multimodal biometrics system has five different ways as shown in Fig.2.

i. Single trait and multiple sensor

Here the single trait from the individual is collected using different sensor and fusion is done to increase the recognition rate.

ii. Multi biometric trait

This is a real sense of fusion [8]. Here the multiple traits from the single individual is collected and fused to improve the recognition rate.

iii. Single trait and multiple units

Here single biometric used to collect different units of a person. For example left and right Iris of the same person.

iv. Single trait and multiple classifier

Here use of single sensor and representation is done in multiple ways.

v. Single trait and multiple instances

The same biometric is used by single sensor, different methods of feature extraction and matching method are combined to improve the recognition rate.

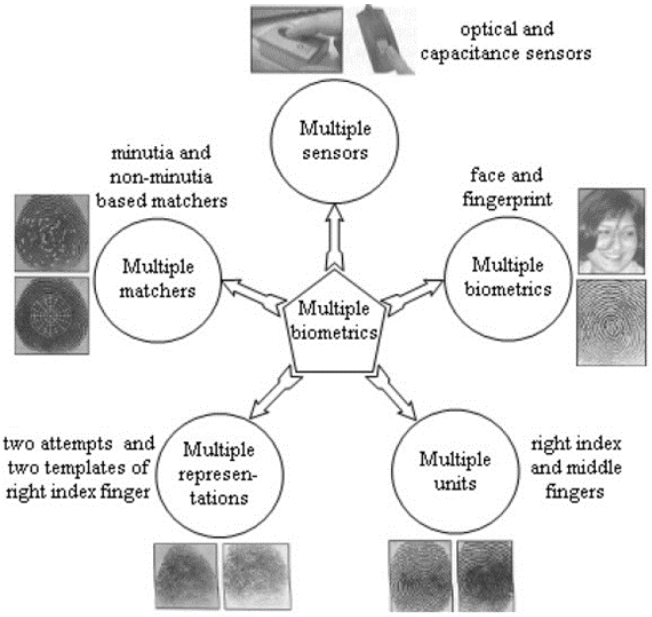

Fig.2. Fusion ways [9, 10]

B. Levels of Fusion

The fusion can be done at any level in the multimodal biometrics system. In this paper an example of Fingerprint and Iris are used to explain fusion levels as shown in Fig.3.

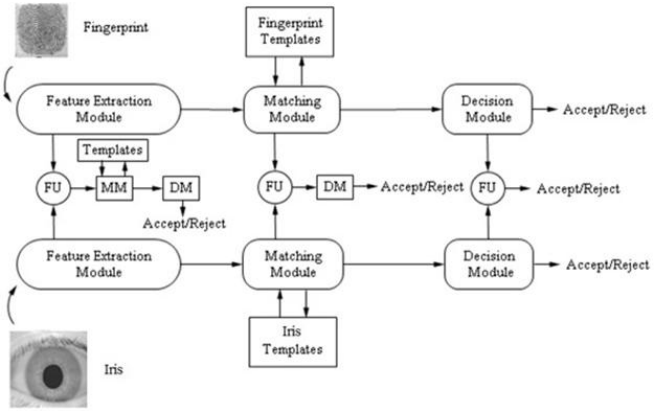

Fig.3. Possible fusion levels (FU: fusion; MM: matching module; DM: decision module) [11]

i. Feature level fusion

In this level the extracted feature of independent trait are fused or combined to form a unique feature vector and further used for classification. Some reduction techniques are used in this level, since feature contains rich information than the individual biometric modality. Therefore feature level fusion achieves more accuracy than others.

ii. Matching score level fusion

In this level of fusion rather than combining extracted features, for the individual features the match score is found. At the final stage the fusion is done with two individual match score and classification is done. The various techniques to fuse two or more individual match score are Linear Discriminant Analysis [LDA] fusion, k-nearest neighbor [KNN] fusion, bayes rule, highest rank, weighted sum, logistic regression, mean fusion, hidden Markov model [HMM] and mean fusion. In this fusion level normalization is required in order to confirm that they belongs to common domain [10, 12]. Statistical estimation of the score distribution and translation into common domain are the two generic steps performed here. The main reason for using matching score fusion is due to less complexity [13, 14, 15, 16, 17].

iii. Decision level

In this level the fusion is done with the decision obtained by every system and gives the final decision. The final classification is based on fusion of output from different modalities [18]. For the better results the fusion should be done at the feature level. However it is hard for fusion at this level [12]. So therefore matching score is the preferred one for fusion.

C. Normalization techniques

In homogeneous score the fusion works well. Commonly the score are heterogeneous. So normalization technique is required to convert them into similar domain. For example the range of score for Ear is 5 to 10 and the range of score for face is 50 to 100. So normalization techniques is very important in score level fusion. Let s represents the output score and s' represents the normalized score. Some common normalization methods are

i. Min-max

$$s'=(s-min)/(max-min)$$

Where min denotes minimum score range and max denotes maximum score range.

ii. Z-Score

$$s'=(s-\mu)/\sigma$$

Where μ denotes the mean of score and σ denotes the standard deviation of score.

iii. TanH

$$s'=½\{[\tanh(0.01(s-\mu)/\sigma)]+1\}$$

D. Modes of operation

There are three different modes in multimodal biometrics system from the view of operational aspects [19]: parallel mode, serial mode, and hierarchical mode as shown in Fig. 4.

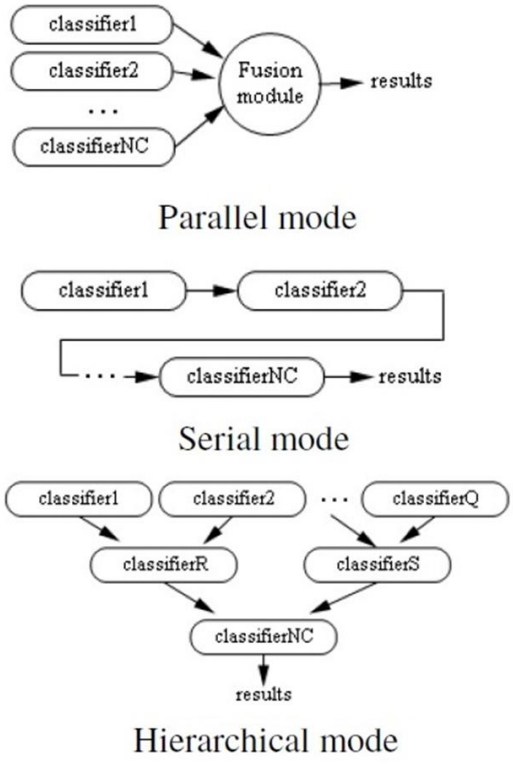

Fig.4. Modes of Operation [9, 20]

Various fusion levels and fusion methods in multimodal biometrics system

TABLE 1. Various fusion levels and fusion methods

Modalities	Fusion levels	Fusion methods
Face and Speech	Matching score	Weighted geometric average
Face and Iris	Matching score	Sum rule, Neural networks
Face and Fingerprint	Matching Score	Product rule
Face, Voice and Leap movement	Decision	Weighted sum rule, Majority voting
Face, Fingerprint and Signature	Matching score	Simple-sum, SVM
Face, Fingerprint and Hand geometry	Matching score	Sum rule, Decision tree, Linear Discriminant Function

Modalities	Fusion levels	Fusion methods
Face and Palm print	Feature	Feature concatenation
Face, Fingerprint and Hand geometry	Matching score	Simple sum rule, Max-rule and Min-rule
Palm print, Hand shape and knuckle print	Feature	Sum, Product, Min and Max
Fingerprint, Face and Hand geometry	Matching score	Likelihood ratio
Face, Ear and Signature	Rank	Logistic regression, Borda count, Highest Rank
Face, Ear and Iris	Rank	Markov chain, Logistic regression, Borda count

Conclusion

Multimodal compared with unimodal biometrics system has more advantages. The multimodal has overcome some of the disadvantages in unimodal system like noisy data, spoof and etc. The future likely has a place with multimodal biometric systems as they ease a couple of the issues saw in unimodal biometric systems. Multimodal biometric systems can incorporate data at different levels, the most prominent one being combination at the matching score level. Other than enhancing matching execution, they additionally address the issue of non-universality and spoofing. With this knowledge, the future work involves fusion of inner-knuckle print and palm print via single sensor. This increases the accuracy and reduces the cost.

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