Applied Soft Computing 47 (2016) 12–20

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Fusion of palm-phalanges print with palmprint and dorsal hand vein

Gopal [a,*], Smriti Srivastava [a], Saurabh Bhardwaj [b], Sandeep Bhargava [a]

[a] Netaji Subhas Institute of Technology, Delhi, India
[b] Thapar University, Patiala, India

ARTICLE INFO

Article history:
Received 21 August 2015
Received in revised form 25 May 2016
Accepted 26 May 2016
Available online 30 May 2016

Keywords:
Personal authentication
Palmprint features
Multimodal system
Score level fusion

ABSTRACT

To ensure the high performance of a biometric system, various unimodal systems are combined to evade their constraints to form a multimodal biometric system. Here, a multimodal personal authentication system using palmprint, dorsal hand vein pattern and a novel biometric modality "palm-phalanges print" is presented. Firstly, we have collected a new anterior hand database of 50 individuals with 500 images at the institute referred to as *NSIT Palmprint Database 1.0* by using NSIT palmprint device. Then from these anterior hand images, database for palmprint and palm-phalanges is created. In this biometric system, the individuals do not have to undergo the distress of using two different sensors since the palmprint and palm-phalanges print features can be captured from the same image, using NSIT palmprint device, at the same time. For dorsal hand vein, *Bosphorus Hand Vein Database* is used because of the stability and uniqueness of hand vein patterns. We propose fusion of three different biometric modalities which includes palmprint (PP), palm-phalanges print (PPP) and dorsal hand vein (DHV) and perform score level fusion of PP-PPP, PP-DHV, PPP-DHV and PP-PPP-DHV strategies. Lastly, we use K-nearest neighbor, support vector machine and random forest to validate the matching stage. The results proved the validity of our proposed modality and show that multimodal fusion has an edge over unimodal fusion.

1. Introduction

Biometrics is a pattern recognition technique recognizing humans based on their physiological or behavioral traits which has been gaining research interest from last few decades [1,2]. A typical biometric authentication system involves data acquisition, feature extraction followed by matching and decision making. The main steps carried out in biometric systems are shown in Fig. 1.

Unimodal biometric system is based on a single trait and it suffers from various limitations such as spoof attacks and several others as stated in literature [3]. While a multimodal biometric system is created by fusing various unimodal systems to ensure high performance of such biometric system as the evidences from different sources are combined together to avoid limitations of unimodal system as shown in Fig. 1. These sources can be from different sensors based on a single biometric or different entities based on a single biometric, like palm feature vector obtained from left and right hands or multiple biometric traits. The information retrieved from individual systems is combined using various schemes such as capturing same information using multiple sensors. For example, the audio samples of an individual are captured using a Hi-tech microphone and an Iphone. Also various traits of an individual are combined to yield a multimodal biometric system. The cost of these systems is high since each modality requires separate sensor and data acquisition phase. For example, face and fingerprint of an individual used for designing a multimodal system. Also, information from similar trait can be combined, for example, palm feature vectors obtained from left and right hands of same individual. These systems are cost-effective, since they need neither new sensors nor new algorithms for feature extraction. The single trait can be processed using multiple algorithms.

Multimodal biometric system shown in Fig. 2 improves the performance of the system by reducing system error rates and produces better recognition rate using some fusion techniques. It increases the robustness of the system in dealing with users who cannot be enrolled with a specific modality and also increases the resistance to spoof attack [4]. By having more than one biometric modality, the reliability of the system improves by making up the loss of one modality with another. Fusion techniques are used to aggregate the feature data extracted from the modalities to produce the improved recognition rates. In multimodal biometric system, complementary information that overcomes the drawbacks of unimodal biometric system is fused. Owing to multiple and independent data obtained from various modalities the multimodal biometric system is more reliable and has higher verification rate and improved accuracy. As a number of modalities are

* Corresponding author. Tel.: +91 8373902293.
E-mail address: gopal.chaudhary88@gmail.com (Gopal).

http://dx.doi.org/10.1016/j.asoc.2016.05.039
1568-4946/

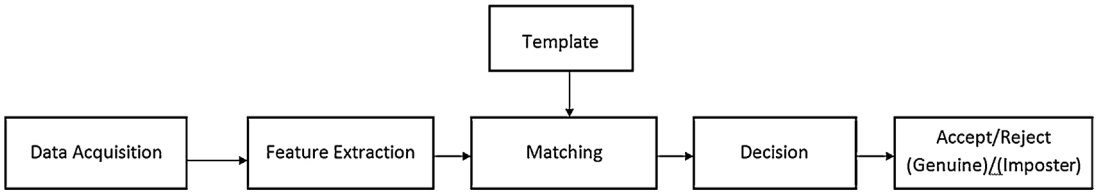

Fig. 1. A typical biometric authentication system involves data acquisition, feature extraction followed by matching and decision making.

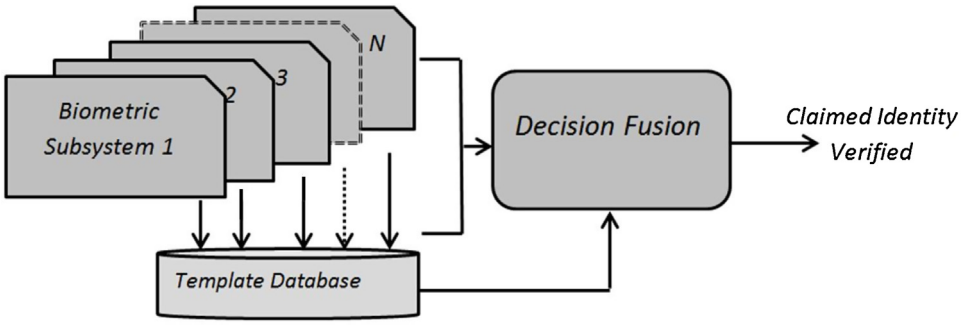

Fig. 2. A general multimodal system.

at our disposal, the choice of suitable biometric trait to authenticate a person becomes an easy task, thus addressing the issue of non-universality. If the biometric sample acquired is not of sufficiently good quality, then the samples from other sources can be banked upon to provide ample discriminatory information to ensure reliable decision-making. Noise in the sensed data from multiple traits has a lesser probability of affecting the performance of a biometric system. Multimodal biometric systems facilitate the choice of the modalities in a given situation. They add more flexibility to the enrollment procedure during user authentication.

The main issues and challenges in the design of multimodal biometric are: non-availability of multimodal biometric database; choice of modalities and choice of fusion technology. Apart from these issues, the performance evaluation of biometric systems is essential in high security applications like defense, government sector, airports, and forensics and also in commercial applications like access control, mobile computing. Biometrics based authentication involves personal data; it may be possible that data collected may be used for some unanticipated purpose. Privacy concerns are related to data collection, unauthorized use of recorded information and improper access to biometric records.

Based on the issues of unimodal biometrics, several multimodal biometric methods are developed and tried with many fusion mechanisms such as face and fingerprint using match score fusion [5]; face and speech [6]; face, voice and lip movement [7]; face, fingerprint and hand geometry at the matching score level [8]; palm-print, hand shape and knuckle print using feature level fusion [9]; integrating iris, face and palmprint [10]; finger vein, fingerprint and the finger-knuckle-print using Kernel Fisher analysis [11]; and fusion of input gestures from multiple modalities was presented [12]. In [13], a biohashing based fusion of palmprint and palm vein is suggested which shows the conversion of features in biocodes for security purposes. Another fusion approach of palmprint and palm vein is presented in [14] which presents opponent-processing and dual-tree complex wavelet transform (DTCWT) are more effective than discrete wavelet transform (DWT) and shift invariant discrete wavelet transform (SIDWT). In [15], biometric approach of car anti-theft system is suggested using fusion of palmprint and palm vein. The conventional sum rule, product rule, max rule, min rule, median rule and majority voting are presented by fusing evidences from multiple classifiers [16]. In 2011, a multimodal biometric system is presented by combining palm-print and finger knuckle-print at the matching-score level [17]. The score level fusion of knuckle, palm-print, and hand geometry is implemented using t-norms [18]. In 2015, hybrid fusion of score level and adaptive fuzzy decision level [19] is also presented which proves that single modality from all four finger knuckle-print can be combined in multimodal fashion.

In this paper, an attempt has been made to improve the performance of a biometric system by using palmprint, dorsal hand vein pattern and a novel biometric modality "palm-phalanges print". A fusion of three different biometric modalities which includes palm-print (PP), palm-phalanges print (PPP) and dorsal hand vein pattern (DHV) has been proposed. We also present score level fusion of PP-PPP, PP-DHV, PPP-DHV and PP-PPP-DHV strategies.

This paper is organized as follows. Section 1 gives an introduction of unimodal and multimodal biometric systems. Section 2 explains the process of database collection. Section 3 gives the idea of "palm-phalanges print" and its feature extraction. Section 4 and Section 5 present the method of palmprint and dorsal hand vein feature extraction respectively. Sections 6 and 7 demonstrate the method of fusion. Section 8 presents the stage wise steps followed in proposed work with graphical representation. Simulation results are shown in Section 9. The paper is concluded in Section 10.

2. Database acquisition

First, we have collected a new anterior hand database of 50 individuals with 500 images (50*10 samples) in biometric laboratory of the institute referred to as *NSIT Palmprint Database 1.0* by using a NSIT palmprint device shown in Fig. 3. Then, this database is used to extract region of interest (ROI) from anterior hand images. The image procurement setup designed here is inherently simple, fast and user-oriented so as to make the data acquisition process simple. Same database is used to extract ROI of palm-phalanges print as shown in Fig. 4. Here, the individuals do not have to undergo the distress of using two different sensors since the palmprint and palm-phalanges print features can be captured from the same image, using NSIT palmprint device, at the same time. In acquired database, fingers are not touching each other but all sample positions are kept varying so as to make the system position invariant and hence optimizing the practicality of the system.