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A Multibiometric System based on Hand Geometry and Palmprint Features

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Abstract. In this paper we propose an identity verification method based on hand geometry and palmprint features. First, the hand geometry features are extracted. Then a region on the palm is selected and palmprint features are extracted. Extracted features would be matched independently with the stored patterns in database. Finally, The calculated scores are fused together by weighted sum rule. Also a genetic algorithm is applied to search appropriate weights. Simulation results conducted on our collected database show that the system achieves excellent performance in terms of totally success rate of 98.61%.

Keywords: multibiometric, hand geometry, palmprint, verification, matching score level fusion, genetic algorithm.

1. Introduction

Biometric systems based on hand images due to having many advantages as user acceptance are one of the widely used of biometric systems. Mainly the extracted features from a hand image are classified in to two category . (a):geometrical features, Including features such as area of the palm, length and width of fingers, etc. (b):palmprint features including principal line, wrinkles, crease and delta point on the palm.

Zanuy provided a hand geometry biometric system [3]. First, a pre-processing step include filtering, binarization and contour extraction is done. Finally the extracted features are classified using a multi-layer perceptron. In other study, contour key point position with ICA[1] algorithm on binary image are used to authentication[5]. Fuertese et al applied fingers width as 80 features. The classification process is done by SVM[4]. In other study the position of the contour key points are used as features[6].

The area of palm has line and wrinkles in different direction and depth. palm image is unique and hence have the ability for authentication. There are three different methods to extract the features of the palm. (a):texture based, (b):line based and (c):appearance based methods. The system proposed by Kumar et al is a sample of researches performed based on texture features[8]. In another study, Fourier transform is used to extract hand texture[14].

In line based methods the palm is considered as an image by numerous line. Wu et al applied directional local line energy as features[9]. Conni et al used principal component analysis and independent component analysis for feature extraction[10]. In other research, authentication is done by using principal component analysis and FLD[2][11]. Ekinci et al applied wavelete transform[12]. Considering obtained subimages, independent component analysis is used for feature extraction[12].

Recently, Multibiometric systems are used to increase discriminant of the accuracy. Yang et al proposed a multibiometric system based on fingerprint, palmprint and hand geometry[1]. Kryzuzuk et al combine face and speech features to produce a multibiometric system[7].

The system presented in this paper is combination of hand geometry and palmprint features. This paper is organized as follow: the proposed algorithm are presented in section 2. Experimental results are addressed in section 3

2. Proposed Method

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[1] Independent component analysis
[2] Fisher's linear discriminant

The proposed method is based on hand geometry and palmprint features. The block diagram of proposed method is shown in Fig 1. As seen both of two system are fed by one image. Matching process in two systems is based on Euclidean distance. Finally, appling score level fusion of matching results, decision making is performed. this system can only verify or reject user. For this purpose, firstly a group of users are registered. Then the mentioned features are extracted and stored in database. In the authentication phase, the user hand geometry and palm features are extracted. Matching process is performed in order to verify or reject the user.

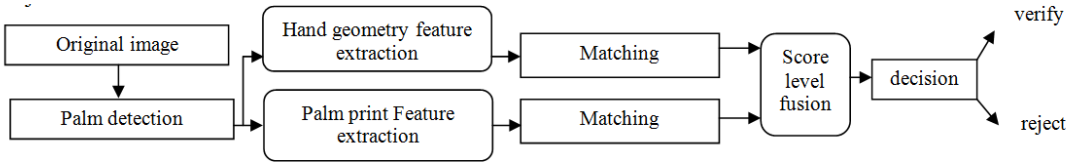


Fig. 1: the block diagram proposed system

2.1. Image acquiring

In the proposed system no PIN is used. there is no specific guidance on the platform, therefore users are free on hand placing. Just asking the users keep fingers apart and place hand in maximally form.

2.2. Palm detection

In this step, firstly a rotational alignment is incorporated by using ellipse fitting of the binary image. Ellipse fitting is performed to estimate ellipticity of hand shape(Fig 2b). Then the position of wrist is obtained and removed(Fig 2c). The hand contour is extracted(Fig 2f), radial distance between the centre of gravity and extracted contour is estimated(figure 2g). The peaks and valleys indicate the fingers. Distance between F1 to the first peak is as the same with distance between first peak to first valley. Similarity, distance between F4 to fourth peak is same with distance between fourth peak to third valley. So F1 and F4 are labeled as the width of the palm.(Fig 2h).

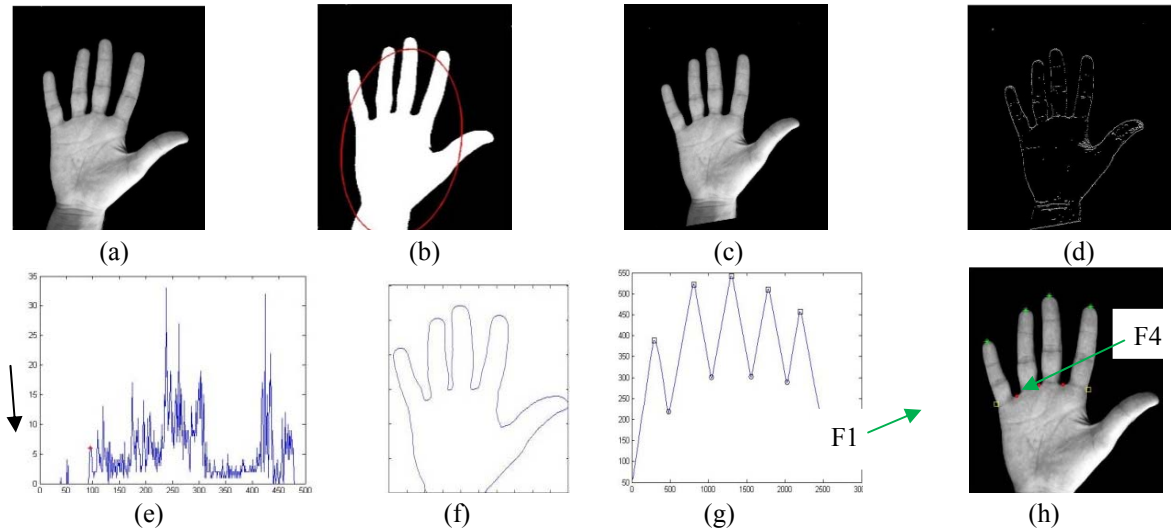
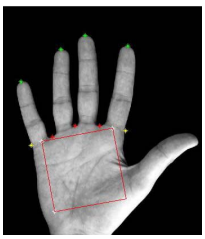


Fig. 2: the palm detection process. (a): original image, (b): ellipse fitting, (c): aligned hand, (d): horizontal edge detection of hand image, (e) projection of (d) image, (f): extracted hand contour, (g):signature of hand contour, (h):labelled fingers valleys and peaks .

Following the palm width estimation, the square region that can be fit on selected two point is chosen as palm ROI. The extracted region is rotated and resized to 300*300 pixels.

2.3. Hand geometric feature extraction

At this step, fifteen geometry features, including length of fingers(except thumb), knuckle width(as eight features) , hand height, palm width and palm height are extracted. Palmprint feature extraction


(a)

(b)

Fig. 3:the palm ROI extraction. (a):palm ROI is detected, (b): ROI is rotated resized to 300*300 pixels.

2.4. Palmprint feature extraction by using gabor filter

At this stage, in order to extract the desired feature of palm is used of a gabor filter. The filter can extract the image spatial frequency information. A gabor filter is a set of middle pass filters witch operate edge detection in different directions. In gabor filter 3 variable include domain, direction and central frequency can be change. But since in this paper we change direction and scale variables only, the gabor filter have change can be seen in Eq1.

$$\psi_k(z) = \frac{\|k\|^2}{\sigma^2} e^{\|k\|^2\|z\|^2 / 2\sigma^2} [e^{ikz} - e^{\sigma^2/2}] \quad (1)$$

Where $k = k_v e^{i\phi\mu}$, $k_v = k_m / f^v$, $\phi_\mu = \pi\mu/8$, μ is orientation and v is scale of gabor filter. k_m is maximum frequency and f is spacing factor in frequency domain. Lades et al illustrate that $\sigma = 2\pi$, $k_m = \pi/2$ and $f = \sqrt{2}$ have best result in recognition[13]. In our experiment we let the number of orientations and scales be 16 and 5, respectively. By using the above value 80 sub image be obtained. In our experiment we let the number of orientations and scales be 16 and 5, respectively. As the result, 80 sub-images are extracted.

The normalized energy value of extracted sub-images are features we applied.(Eq 2,3).

$$E_a = \sum_{\alpha,\beta \in ROI} \|f_a(x,y)\| \quad (2)$$

$$E_N = E_a / \sum_{a=1}^{80} E_a \quad (3)$$

Where f_a is the a^{th} sub image. E_a, E_N are energy and normalized energy values respectively.

2.5. Matching

In this research, the classification process is performed by Euclidean distance. In order to verify or deny the user a threshold value is used. If the matching scores are above the threshold value, the user is verified otherwise rejected.

2.6. Decision process

Several method have been used to combine of systems are classified into four categories: (A): sensor level fusion: in these systems, the input data is combined to make accuracy higher. (B): feature level fusion: in these methods the feature vectors are extracted from the systems combined to make a unite vector with higher discriminant accuracy. (C): matching score level fusion: in this method, the matching scores are estimated separately(for each biometric system). Then the results are combined to make unite matching score with higher authenticity. (D): decision level fusion: in this case, the final decision is done based on the decision scores of each biometric systems. The third method, matching score level fusion has shown better performance compared to other methods[16]. In this article, the weighted scores, is used to combine matching results. Since there is two matching systems, the total score is calculated by sum of the two matching scores(Eq. 4):

$$\text{Total score} = \lambda_1 w_1 + \lambda_2 w_2 \quad (4)$$

Where λ_1, λ_2 are weights and w_1, w_2 are matching scores obtained from hand geometry and palmprint verification systems.

In order to find best results of λ_1 , λ_2 we applied the genetic algorithm. Genetic algorithm is a programming technique for optimization problems. Since λ_1 and λ_2 include large range of weights, genetic algorithm could be used to estimate the best value of weights which maximize the TSR[3] in minimum threshold value.in other word, the threshold value and the two score weights are parameters which are estimated using the genetic algorithm.

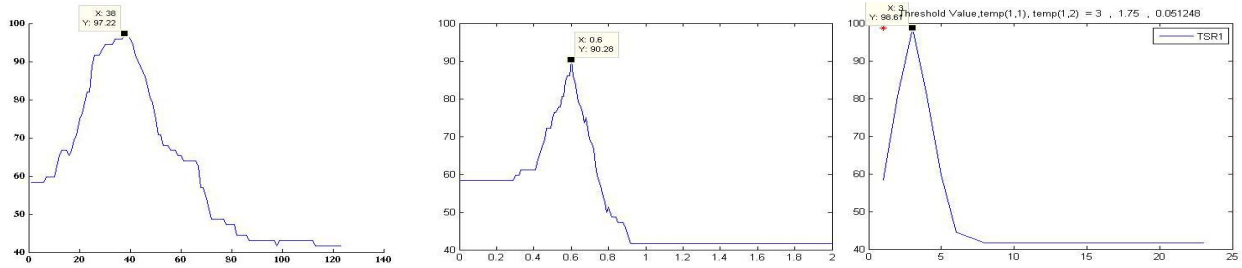
3. Experimental Results

Our database consists of 144 images of 72 different users. in fact, two image are taken of each user. The image acquired from right hand by a digital camera. The size of all image are 536*646 pixels. In order to compare the systems with each others, we used the TSR, FAR[4] and FRR[5] parameters. We compare the totally successfully rate in verification based on palmprint by using gabor filter with the result reported using different orientations, scales and blocks of image, as shown in table 1.

Table 1: TSR, FAR and FRR based on different orientation, scale and block of image

Orientations and scales	Max(TSR)	FAR	FRR
(with 155*155 primary block of image) 8&5	81.9441%	0.0714	0.3333
(with 155*155 primary block of image) 8 &3	68.0556%	0.2143	0.4667
(with 128*128 primary block of image)16&5	88.8889	0.0952	0.1333
(with primary 155*155 block of image)16&5	**90.2227%**	**0.0714**	**0.1333**
(resized image to 128*128)16&5	77.7778%	0	0.5333
(resized image to 155*155)16&5	77.7778%	0.0238	0.5000
Whole of image(300*300)16&5	80.5556%	0.1190	0.3000

figure 1 shows best TSR for each system. As seen, the best result for verification is 97.22% and 90.28% based on hand geometry and palmprint methods. By using matching score level fusion ($\lambda_1 = 1.75$ and $\lambda_2 = 0.051248$) the best result raise to 98.61%.



(a) (b) (c)

Fig. 4: (a) & (b): TSR curve versus the threshold value in hand geometry and palmprint methods, respectively ,(c) TSR versus threshold value in combined method (horizontal & vertical axis indicate the threshold & TSR values, respectively). sanely The false acceptance rate is more important than false rejection rate, therefore less FAR is more appropriate. Figure 7 indicated the FAR versus FRR values.

Note that the classification process of hand geometry and palmprint are based on simple and normalized Euclidean distance, respectively. Table 1 shows results for classification of hand geometry method based on simple and normalized Euclidean method. As seen the simple method have better result.

[3] Totally success rate
[4] False acceptance rate
[5] False rejection rate

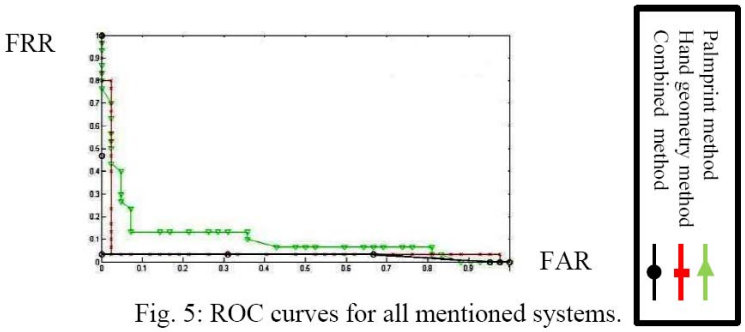


Fig. 5: ROC curves for all mentioned systems.

Table 2: verification results based on euclidean and vormalizad euclidean distand.

	Max(TSR)	FAR	FRR
Simple Euclidean	97.2222%	0.0238	0.0333
normalized Euclidean	94.4444%	0.0238	0.1000

4. Conclusion

In this paper, we have introduced a new multibiometric system based on hand geometry and palmprint features. The proposed system acquires hand images in peg-free manner. Each biometric system extract features, independently. Match scores from hand geometry and palmprint matcher are combined. The fusion of two individual biometric matching score is done by weighted sum rule. Our experimental result on a database of 144 image demonstrate the robustness of our proposed system. In future a attempt will be made to increase database size.

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