Multimodal Biometric Identification System based on Cascaded Advanced of Fingerprint and Finger Vein Images and AND Rule at Decision Level Fusion

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Abstract: The multimodal identification system can integrate a variety of biometric characteristics. The main advantage of multibiometric system against traditional single biometric is achieving the recognition process more accurate and safe. In this paper, we will present a multimodal biometric recognition system that combines fingerprint and finger vein. The features in theses biometric traits are extracted to identify that individual is genuine or impostor using minutia points for fingerprint and Histogram of Oriented Gradient for finger vein.In the first stage, cascade multimodal biometric system based on the both biometric modalities is applied. In the second stage, the fusion is accomplished at decision level method based on AND rule using multimodal biometric recognition system. The simulation results have demonstrated that the proposed fusion algorithm performs increase probability the accuracy to 99,85 than the other system based on unimodal characteristics.

1 INTRODUCTION

In recent years, the biometric system necessity has been rapidly increased. The biometric recognition is required reliable to distinguish one individual from another using measurable morphological (such as fingerprint, face, iris, etc.) or behavioral (for example voice, signature, etc.) features. With these characteristics including being less susceptible to verification being stolen or forgotten. It is used for criminal identification, immigration and naturalization service, securing access to buildings or personal objects, supporting anonymous transactions, etc.(Cherrat et al., 2017).

The most common biometric system is fingerprint recognition. It is considered an excellent biometric modality for identification or verification the person, especially in the latest smart phones and consumer devices. Compared to other biometric traits, the finger vein modality has achieved popularity in biometric recognition because of the variety advantages given by these systems for example, 1) the vein of each person are completely unique and different 2) it is identified as being less prone to modify with age and growth (3 the finger veins biometric is easily acquired using sensor capable of capturing or the NIR (Near-Infrared) light source 4) the vein structure is hidden inside the skin. Thus, the possibility of spoof the human recognition system is very complex (Khellat-Kihel et al., 2016).

The general structure of biometric recognition system consists of four main steps. In the first one, the acquisition of biometric image is process of getting a digitalized image of a person using specific capturing device. In the second step, the pre-processing is allowed to improve overall quality of the captured image and to correct its orientation . After that, the region of interest is localized. It is the process of obtenting all important data needed for recognition. In the next step, the features information are extracted using different algorithms. In the last step, generally, the matching of the extracted characteristics is applied in order to perform the recognition of the person.

The multimodal biometrics combines two or more different biometric modalities and reduces certain limitations of systems based on one modality such as spoof attacks,non-universality, noise in sensed data,inter-class similarities and intra-class variations. Thus, the recognition system based on fusion of multibiometric is most recommended for significantly

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improving the system performance and reducing the error rate the identification or verification of the individual. This fusion can be applied at the sensor level, the feature extraction level, the matching-score level, rank level and at the decision level. The multimodal biometric systems are classified as multi-instance, multi-sensor, multi-algorithm, multi-modal and hybrid systems (Khellat-Kihel et al., 2016).

The rest of the paper is separated into four sections. In the section 2, the related works in the field are reviewed. Section 3 discusses the proposed algorithm. Experimental results have been analysed and discussed in Section 4. Finally, the conclusion is presented in the last section.

2 RELATED WORKS

Many techniques have been proposed of the multimodal biometrics system. Ross et al (Ross, 2003) presented different levels of fusion and score level fusion on the multimodal biometric system. Singh.al (Singh et al., 2004) proposed biometric recognition system based on face combining visible and thermal Infrared (IR) images at sensor level. Son (Son and Lee, 2005) have been subjected a fusion of face and iris at feature level. Ross.al (Ross and Govindarajan, 2005) presented hand and face combined at feature level. Moreover, the experiments were applied in three different scenarios. At the fusion of match scores, Jain.al (Jain and Huang, 2004) proposed linear discriminant function and the decision trees. Different fusion techniques and normalization methods of fingerprint, hand geometry and palm-print biometric sources are achieved by Yang.al (Yang and Ma, 2007). Another multimodal biometric system based on multi-instance iris recognition system using a fusion of right iris and left iris for the same individual is studied by Wu.al. (Wu et al., 2007). Jain.al (Jain et al., 1999) introduced a multimodal biometric system using face, fingerprint, and voice. Yang.al (Yang, 2018) presented a multi-biometric system cancelable using fingerprint and finger-vein, which combines the minutia points of fingerprint and finger-vein image feature based on a feature-level of three fusion techniques. The fusion multimodal biometric system based on fingerprint and finger-vein at score level using four score fusion approaches (min score, max score, simple sum, user weighting) and three score normalization techniques (min-max, z-score, hyperbolic tangent) is developed by Vishi.al (Vishi and Jøsang, 2017).

3 PROPOSED METHOD

In first level of our algorithm, fingerprint image is enhanced using gabor filter technique, binarized and passed to thinning algorithm. Then, the features points are extracted using ridge ending and bifurcation uniformly namely minutiae. In the final step, the comparison of minutiae information provided from the registered database, and the query fingerprint is presented to the matching. In the second level, the Linear Regression Line have been utilized to solve the orientation of misalignments of finger vein images. Next, the region of interest of image is obtained using canny method. After that, the histogram equalization is applied to enhance the cropped finger vein image.Furthermore, the features extracted is based on Histogram of Oriented Gradient algorithm. Finally, the score provided is compared and machted with stored fingervein templates stored in the database. If the first level is not identified then the second level works. The fusion is applied at cascaded advanced decision level. If the first level is passed then the second level avoids for matching fingervein extracted. In this section, we detail the proposed technique which is illustrated in Figure 1. The details of each phase are represented in the following.

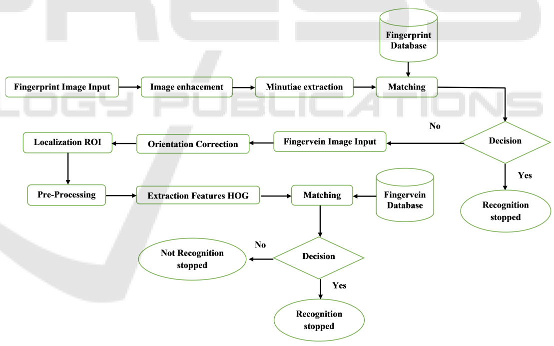


Figure 1: Block diagram of proposed algorithm for finger vein image recognition

3.1 Fingerprint Recognition

3.1.1 Image Enhancement

To overcome the background noise, non-uniform illumination and low contrast of the fingerprint image captured, the preprocessing is important step for characteristic extraction and then the matching. The mean and variance are used to normalize and estimate the orientation of input image. After that, the frequency image is computed from which the region mask is provided using block classification of resulted image. Then, gabor filters applied to normalized image (Hong et al., 1998).

3.1.2 Feature Extraction

The features points are extracted from fingerprint image such as ridge ending and bifurcation uniformly namely minutiae. Before extracting the minutiae, the binarization method is applied using block with size 3x3. This process is transformed the 8 bits gray image to 1 bit with 1 value for the valleys and 0 value for ridges based on a given threshold. Next, morphological technique processing (dilatation and erosion) is used as postprocessing to achieve more compact blocks for reducing the noise region. Moreover, the thinning operation is applied to remove basically the redundant pixels until having a single pixel width (Cui and Yang, 2011). Finally, the bifurcation and ending points are detected by computing black pixels of 8-directional nearest for each pixel point in fingerprint image. If the central pixel is black and has 3 black values nearest, then this pixel is a bifurcation. When the number of black nearest is just 1, the feature point is represented ending. The connection number (CN) for a given ridge can be represented in equation 1 . Hence, the minutea characteristic extraction of fingerprint pattern is represented by the following parameters, 1) Type of the ridge, 2) x-coordinate, 3) y-coordinate, 4) θ-orientation.

$$CN = \frac{1}{2}\sum_{i=0}^{7}|P_i - P_{i+1}| \quad (1)$$

where P_i is the pixel value at index i and P_8=P_0

3.1.3 Features Mathching

The minutiae feature extraction of fingerprint pattern is represented by the type of ridge, the spatial coordinates x, y and orientation of minutiae points. The Euclidian distance is used to find number of matched two minutiae pairs. This distance is described as follows :

$$E_d(M_i, M_j) = \sqrt{(x_i - x_j)^2 + (y_i - y_j^2)} \quad (2)$$

$$A_d(M_i, M_j) = min(|\theta_i - \theta_j|, 360 - |\theta_i - \theta_j|) \leq \theta_0 \quad (3)$$

where M_i and M_j are the extracted minutiae points pairs from the template in the enrolled database and the input query fingerprint image respectively. A_d (direction difference between M_i and M_j) is smaller than an angular tolerance θ_0.

The similarity score S_f based on minutiae points between the queried and stored fingerprint images is calculated using equation (6).

$$M(M_i, M_j) = \begin{cases} 1 \ \ if(E_d \leq r_0)and(A_d \leq \theta_0) \\ 0 \ \ Otherwise \end{cases} \quad (4)$$

where r_0 is allowed the diffrence between M_i and M_j.

$$N_m = \sum_{i=1}^{n}\sum_{j=1}^{n} M(M_i, M_j) \quad (5)$$

$$S_{Fscore} = \sqrt{\frac{N_m^2}{N_i N_j}} \quad (6)$$

where N_m is the total matching of M_i and M_j. N_i and N_j are total number of M_i and M_j respectively.

3.2 Fingervein Recognition

3.2.1 Orientation Correction

In this section, the obtained region of finger vein images is needed to determine that images are oriented correctly or not. The orientation corrected angle can affect to accurately extract feature extraction and matching. Thus, Linear Regression Line is applied to compute the estimated orientation angle θ represented in the figure 2. First, all middle points are represented the line function of the finger vein image, which is defined in equation (7). Next, the orientation angle value is calculated by using equation (8). Finally, these images are considered normal, if orientation angle value is equal to 0, otherwise the finger vein image is not correctly oriented. The figure 3 represents the results of the orientation corrected angle.

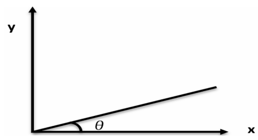


Figure 2: Orientation angle detection.

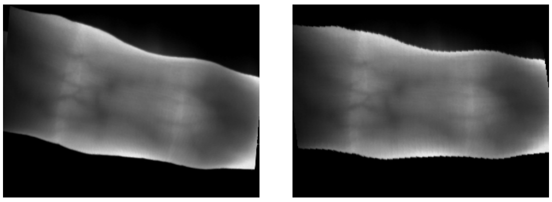
$$y = ax + b \quad (7)$$

$$a = \frac{\sum_{i=1}^{M}(x_i - \bar{x}) - (y_i - \bar{y})}{\sum_{i=1}^{M}(x_i - \bar{x})^2} \quad (8)$$

$$\bar{x} = \frac{1}{M}\sum_{i=1}^{M} x_i \quad , \quad \bar{y} = \frac{1}{M}\sum_{i=1}^{M} y_i \quad (9)$$

$$\theta = \begin{cases} -\arctan(a) & if(a < 0) \\ \arctan(a) & if(a > 0) \\ 0 & if(a = 0) \end{cases} \quad (10)$$

where x_i = 1,2,3....M, i= 1,2,3....M. Therefore, the orientation angle value θ between the estimted line and X-axis is calculted using equation (10).

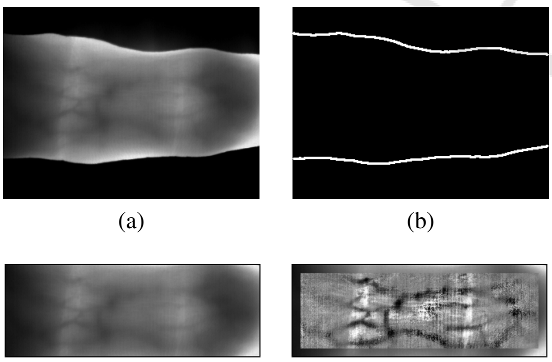


(a) (b)

Figure 3: Orientation correction of finger vein image : (a) finger vein image distortion oriented ; (b) finger vein image oriented correctly

3.2.2 ROI Detection

When the finger vein image is correctly oriented, the regions of interest will be obtained. This region has the ridge and lines patterns of the finger vein that is exploited for recognition. Canny technique is the famous edge detector algorithm. It is developed by (Canny, 1986). For this reason, Canny method is adopted to extract the ROI of finger vein image. Firstly, this technique is applied to obtain the edge outline of finger vein image. After that, the inner rectangle is used to extract the ROI. The result of ROI of finger vein image using Canny edge detector scheme is shown in Figure 4.



(a) (b) (c) (d)

Figure 4: Illustration of ROI extraction and pre-processing of finger vein image : (a) Original image ; (b) Canny method ; (c) ROI detected ; (d) ROI pre-processing

3.2.3 Pre-processing

After extracted the ROI providing Canny edge detector, we evaluate the sharpness and contrast of finger vein image. Thus, local histogram equalization is applied for image contrast enhancement (Kim, 2001). The essential data of finger vein image can be shown clearly which is represented in Figure 4.

3.2.4 Feature Extraction Method

HOG (Histogram of Oriented Gradients) descriptor has shown outstanding success in recognition system. HOG has been popular used as one of the better features to acquire local shape points or the edge. For this advantage, this technique is applied in our algorithm for feature extraction in order to recognize the person. The HOG orientation of each cell, small connected areas, is separated. For better compensating the illumination, the normalized histogram is obtained by accumulating a measure of the local histogram gradient orientation over blocks based on the results to normalize each cell in the block. These histograms are combined to represent the HOG feature (Dalal, 2005). The process of extracting the HOG descriptor is illustrated in Figure 5.

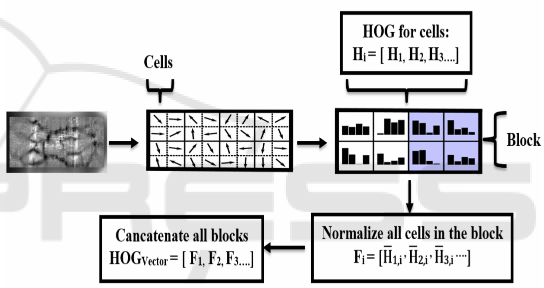


Figure 5: Illustration of HOG descriptor extraction

3.2.5 Features Comparison

The generated similarity score based on HOG features Before to compute the generated similarity score S_{Hscore} based on HOG features, Hamming distances is computed to match scores between the finger vein template stored in database and the input test template as calculated using equation (11). The similarity score of HOG is given by equation (12).

$$D_H = \sum_{i=0}^{k} |F_{Ei} - F_{Ti}| \tag{11}$$

where F_{Ei} and F_{Ti} are the extracted HOG from the template in the enrolled database and the input query finger vein image respectively.

$$S_{Hscore} = min(D_H) \tag{12}$$

4 EXPERIMENTS AND RESULTS

The experimental operation platform in this study is described as follows: the host configuration: CPU

Intel Core2 Duo at 2.00 GHz, RAM 3.00 GB, runtime environment: Microsoft Visual Studio C++ 2013 with OpenCV library. In order to validate the proposed algorithm, the results have been tested on the VERA Fingervein Database (Tome, 2015) and the public Fingerprint Verification Competition 2004 dataset (Maio et al., 2004). The performance measure is accuracy rate as defined by equation (13).

$$Accuracy = \frac{FAR + FRR}{Total_{NumAcc}} \tag{13}$$

where FAR (False Acceptance Rate) is the probability of unauthorized users that are not recognized over the total number tested, FRR (False Reject Rate) describes the percentage of authorized users that are not recognized falsely to the total number tested and $Total_{NumAcc}$ is the total number access.

Table 1: The accuracy rate for different recognition biometric system results.

Algorithms	Accuracy Rate (%)
Fingerprint using Minutiae	96,93
Fingervein using HOG	97,45
Cascaded Multimodal	99,85
Cascaded Multimodal and And Rule	99,28

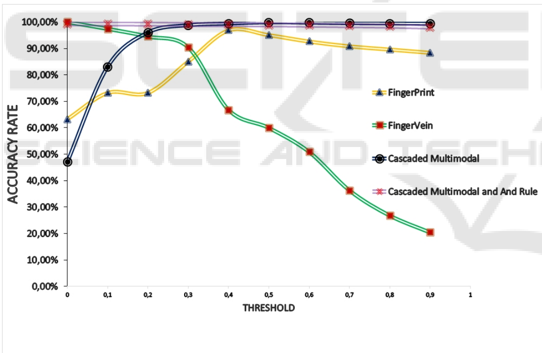


Figure 6: Recognition results with comparison of algorithms at the accuracy rate.

Table 1 shows the performance of accuracy rate based on single biometric system using fingerprint, fingervein images and the cascaded multimodal recognition biometric system using fingerprint and fingervein. Figure 6 shows the ROC curves using different recognition methods. In comparison with single biometric system, our proposed algorithm especially with the cascaded multimodal biometric system using fingerprint and fingervein shows superior performance in terms of accuracy rate with 99,85% with where Fingerprint using minutiae points fingervein using HOG, cascaded multimodal and And Rule give 96,93% ,97,45% and 99,28% respectively. We can conclude from these results that the cascaded multimodal recognition biometric system using fingerprint and fingervein leads to an improvement in recognition biometric system performance.

5 CONCLUSIONS

This paper presented multimodal biometric identification system based on cascaded advanced of fingerprint and finger vein images and AND rule at decision level fusion in order to achieve accurate recognition of the person. In first step level, the fingerprint image is enhanced based on gabor filter algorithm, binarized. Moreover it is passed to thinning technique, extract minutiae points and finally the matching. If the matching score is greater than the given fingerprint threshold then recognition is stopped. Else the second level is started with fingervein image. The orientation correction, ROI detection based on canny method and local histogram equalization to improve the quality of fingervein image are applied.After that, the important features are extracted using HOG method. In the next level, the recognition of the both biometrics sources are verified at decision level based on AND rule. The results have shown that the proposed work performed better in personal identification rate than others based solely on one algorithm. The proposed method can be further extended by matching the features with other metrics.

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