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Hand vein recognition based on the connection lines of reference point and feature point

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HIGHLIGHTS

- A new hand vein recognition algorithm based on reference point is proposed.
- The reference point are extracted from intersection points and endpoints.
- The distances between the reference point to the feature points are used as recognition features.
- The angles between the adjacent connections are used as recognition features.
- Experiments show that the algorithm is able to overcome the influence caused by image rotation.

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ABSTRACT

According to the essential characters of the image topology, a new hand vein recognition algorithm based on the connection lines of reference point and feature points is proposed. In this method, the intersection points and the endpoints of the vein image are used as feature points. After the intersection points and the endpoints selected as feature points, the reference point for image matching are extracted from these points. The relative distances between the reference point and the feature points and the angles between the adjacent connections of the reference point and feature points are calculated and used as recognition features. Finally these two features are combined for hand vein recognition. This method can effectively overcome the influence on the recognition results caused by image translation and rotation. Experimental results show that the proposed algorithm is able to achieve hand vein recognition reliably and quickly.

1. Introduction

In the present, people put forward higher requirements for information security. The traditional identification methods such as credentials and passwords have been far from being able to meet today's market demanding. Biometric is a new identification technology, which is more reliable than traditional identification way [1–3]. Hand vein pattern recognition is one of the focus in the field of biometric identification in recent years. Noncontact inspection is needed and users do not reject it for fearing of data left over. As the subcutaneous tissue, it is difficult to forge the distribution patterns of vein, less susceptible to contamination and damage. So, the higher acceptance and security can be ensured [4–6].

At present, the hand vein pattern recognition algorithm mainly focus on the analysis and calculation of vascular structural features. Cross et al. used the skeleton images of the registered samples to match with the skeleton images to be identified samples [7]. Shahmi et al. used the binary hand vein image to template match [8]. Lin Xirong et al. proposed a identifying method based on the position corresponding relationship of endpoints and the intersection in the skeleton image [9]. All algorithms mentioned above identify the patterns of hand vein with the corresponding location of the vein network between samples to be identified and registered samples, therefore it is more sensitive to the placement of the back of the hand. In practice, the rotation and translation of the placement of the back of hand will be inevitable, it will affect the recognition performance. In some improved recognition algorithms, the registered samples are rotated or translated in a small range, and then make the transformed samples match with the samples to be identified [8–11]. Using this method, it not only brings stringent requirements for the placement of back of the hand, but also increases the complexity of the algorithms. Kang Wenxiong and Deng Feiqi proposed a method base on angle matrix of feature point, it will increase the computation time because of the obtention of multisection points [12].

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In this paper, we propose a new hand vein recognition algorithm based on the connection lines between reference point and feature points. In this method, the intersection points and the endpoints of the hand vein image are used as feature points after preprocessed. Then the reference point is selected according to the relative distance between the feature points. The relative distances between the reference point and the feature points and the angles between the adjacent connections of the reference point and feature points are calculated and used as recognition features. Finally these two features are combined for hand vein recognition. Experimental results show that the proposed algorithm is able to achieve hand vein recognition reliably and quickly and effectively overcome the influence on the recognition results caused by image translation and rotation.

2. The determination of the reference point

Let P and Q respectively denote the set of feature points of the two hand vein images to be matched, that is $P\{p_{1,}p_2 \ldots p_m\}$ and $Q\{q_{1,}q_2 \ldots q_m\}$. The reference points are a pair of points p_i and q_k which have the highest credibility compared with other pairs of points, and used as the benchmark for image matching. The credibility of p_i and q_k can be obtained as follows.

The distance E_{ij}, F_{kl} between $p_{i,}$ q_k and all other feature points in P, Q are respectively calculated.

$$E_{ij} = |\overline{p_i p_j}|, \quad j = (1, 2 \ldots m) \tag{1}$$

$$F_{kl} = |\overline{q_k q_l}|, \quad l = (1, 2 \ldots n) \tag{2}$$

The number of the same distance between E_{ij} and F_{kl} is called matching credibility of p_i and q_k.

In practical applications, there may be error due to the relative position between the feature points considering the different shooting conditions. Therefore, E and F are considered equal when $\| |\overline{p_i p_j}| - |\overline{q_k q_l}| \| \leqslant e$,where e is the range of error which can be obtained by a great deal experiments (e = 0.0006 in this paper). p_i and q_k can be served as the reference points when they are the same type of feature points and seen as the maximum matching credibility.

For example, if there are five feature points of the two hand vein image. E_{3j} and F_{4l} are calculated and they have the maximum mathing number 4, so p_3 and q_4 can be served as the reference points.

3. Hand vein recognition based on the relative distance and angle

After the reference point is determined, the two hand vein images can be preliminarily judged matching or not by the number of the same distance (it is the maximum matching credibility which is set to M) between the reference point and the feature points. According to threshold method, when M is less than the set threshold, the two images could be considered irrelevant. On the contrary, it is determined by the angles between the connection lines of reference point and feature point that the two images match or not. The reference point and the corresponding equidistant feature points of the two images were respectively connected. The angles between the adjacent connections were calculated. The two sets of angles can be denoted as:

$$\theta_p\{\theta_{p1}, \theta_{p2} \ldots \theta_{pM}\}, \theta_q\{\theta_{q1}, \theta_{q2} \ldots \theta_{qM}\}$$

The number of the equal or approximately equal angles of the two sets is calculated, if it is larger than the pre-set threshold, the matching successes, otherwise, the matching fails. The angles considered equal or approximate can be expressed as:

$$\|\theta_{pi} - \theta_{qi}\| \le e', \quad (i = 1, 2 \ldots M) \tag{3}$$

where e' is the range of error which can be obtained by a great many experiments (e' = 0.005 in this paper).

4. Experimental results and analysis

The method proposed in this paper has been applied in experiments of hand vein recognition. Fig. 1 is the flow chart. After the original hand vein image is read, the effective field is extracted as a new image. Then the new image is segmented and improved by thinning and restoration. Finally, we can obtain the skeleton of the hand vein image. According to the skeleton, the reference point is got from all feature points, so the vein pattern recognition of two hands can be made.

4.1. The location of the effective area of the hand vein image

The location of the effective area of the hand vein image means finding the purposeful region for feature extraction from the hand vein image.

In this paper, hand vein image is divided based on the threshold method as is shown in Fig. 2, Fig. 2a is original hand vein image, Fig. 2b is a new image after segmentation. As is shown in Fig. 2b, the original image is divided into two parts: the target (white area) and background (black area).

In order to extract the effective area of the hand vein image after segmentation, the coordinates of centroid of the target image should be calculated first by a formula expressed as:

$$g_I = \sum_{i=0}^{M}\sum_{j=0}^{N} ic(i,j) \Big/ \sum_{i=0}^{M}\sum_{j=0}^{N} c(i,j) \tag{4}$$

$$g_J = \sum_{i=0}^{M}\sum_{j=0}^{N} ic(i,j) \Big/ \sum_{i=0}^{M}\sum_{j=0}^{N} c(i,j) \tag{5}$$

where $G(g_I, g_J)$ represents the centroid, M and N are the number of rows and columns of the target image, $c(i, j)$ can be calculated by the following formula:

$$C(i,j) = \begin{cases} 1, (i,j) \in H \\ 0, (i,j) \notin H \end{cases}$$

where H is the target image.

Then the largest inscribed rectangle determined by the centroid in the target image can be used as the effective region of the hand vein image. Fig. 3 shows the effective region.

4.2. Image segmentation

In this paper, the hand vein image is segmented by Niblack [13] dynamic threshold method, and the threshold can be calculated as follows

$$T(x,y) = m(x,y) + ks(x,y) \tag{7}$$

where k is a correction coefficient, (x, y) represents a pixel point of vein image, $T(x, y)$ is the threshold of this point, $m(x, y)$ and $s(x, y)$ is the mean value and the standard deviation of $r \times r$ neighborhood of it, respectively, they can be calculated by formula (8) and (9),

$$m(x,y) = \frac{1}{r^2} \sum_{i=x-r/2}^{x+r/2} \sum_{j=y-r/2}^{y+r/2} f(i,j) \tag{8}$$

$$s(x,y) = \sqrt{\frac{1}{r^2} \sum_{i=x-r/2}^{x+r/2} \sum_{j=y-r/2}^{y+r/2} (f(i,j)^2 - m(x,y)^2)} \tag{9}$$

where f is the vein image.