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Hand vein recognition based on PCET

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ABSTRACT

A new feature extraction algorithm based on polar harmonic transforms (PHT) is presented, the accomplishment of the new algorithm involves several steps. First, we design the power-controlled multispectral vein acquisition handset to establish high-quality hand vein database. Second, we propose an improved valley-shaped enhancement operator with Niblack algorithm to realize vein segmentation. Third, we design experiments to compare the capability of the several invariant moments including Hu, Zernike, PST, PCT, PCET on the feature description of the different samples and the same samples with different geometric changes. Finally we choose PCET to do the matching experiment and we also use Hu to do the experiment so as to show the superiority of the PCET. The result is that the PCET can achieve an error equation rate of 0.861% and the Hu just achieves 14.51%.

1. Introduction

In the present, hand vein recognition has become one of the focus in the field of biometric identification with the character of noncontact inspection, uniqueness, universality, stability and scalability [1–4].

Because of the noncontact acquisition method of the hand vein, it is inevitable that the unexpected geometric changes including rotation, shift, zooming etc can be brought to the image acquired. As a result, the recognition rate is far from satisfactory. Concentrating on these problems, the search is not too much. The SIFT description [5] is used in the key points of palm vein matching and three local invariant feature extraction algorithms [6]: scale invariant feature transform (SIFT), speeded-up robust features (SURF) and affine-SIFT (ASIFT) for hand vein recognition. This method of using such invariant description can achieve good effect, but all these three description operators require high feature dimension which means more time-consumption in feature extraction. In Refs. [7,8], the idea of little range of shift and rotation change to the registered samples is introduced to decrease the influence of geometric changes on the recognition. This method achieve the effect of decrease the FRR and FAR in a restricted degree, but it increase the amount of samples resulting in more time-consumption while increasing recognition a little. There are also some method focusing on the rotation correction in the process of ROI extraction, its effect is extremely limited and does not have universal applicability.

In this paper, we propose a new feature extraction algorithm based on polar harmonic transforms (PHT) to realize the hand vein recognition. The innovation of our work contains two parts. First, we propose an improved valley-shaped enhancement operator with Niblack algorithm to realize vein segmentation, and it gets better segmentation effect than the traditional three main methods including mean method, Niblack and OTSU in the experiment results we get. Second, we design experiments to compare the capability of the several invariant moments including Hu, Zernike, PST, PCT, PCET on the feature description of the different samples and the same samples with different geometric changes and get the result that PCET performs better

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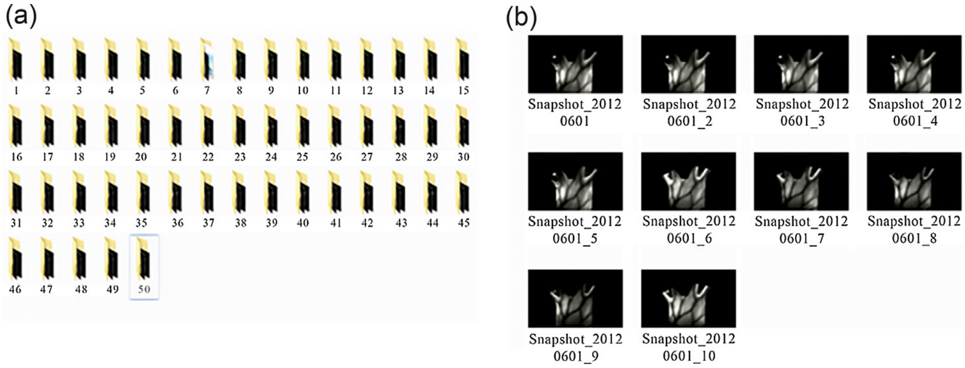

Fig. 1. Database of hand vein images. (a) Sample database; (b) hand vein images of one sample.

than the others, and then we choose PCET to do the matching experiment and we also use Hu to do the experiment so as to show the superiority of the PCET. The result is that the PCET can achieve an error equation rate of 0.861% and the Hu just achieves 14.51% which proves the feasibility and superiority of PCET in vein feature description.

2. Basis of experiment

2.1. Establishment of experimental database

Vein recognition has broad application prospects because of its unduplicated and unchangeable features, it is also hard to be damaged than fingerprint recognition. But there is still not a complete and public database of hand vein image. Therefore, to obtain high-quality hand vein image is the most important prerequisite for the follow experiment design.

We design an acquisition device made up of multispectral LED groups with power-control set on the basis of taking the optical properties of hand vein biological tissues into account, and we choose 50 volunteers taking the difference of hand thickness, ages and sex into consideration to establish a sample database including 500 images of high quality with the device. Fig. 1 shows the images of the database.

2.2. PHT theory

The definition of PHT(polar harmonic transforms) is put forward by Yap [9] etc. in 2010. It can be divided into three different definition according the basic function it adopted, which are respectively PCET (Polar Complex Exponential Transform), PST (Polar Sine Transform),PCT (Polar Cosine Transform).

For images defining on a continuous domain, it is required that protecting the horizontal and vertical coordinates of the image onto the domain [−1,1] before making polar harmonic transforms. The formula of the polar harmonic transforms is:

$$M_{nl} = \frac{4}{\pi N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left[H_{nl}{}'(x_i, y_i)\right]^* f(x_i, y_i)' \tag{1}$$

The definition of $H_{nl}(r,\theta)$ is

$$H_{nl}\left(r, \theta\right) = R_n(r)\,e^{il\theta} \tag{2}$$

n represents the order degree while l represents repeatability which are both arbitrary integers $(|n| = |l| = 1,1,2\ldots,\infty)$,$[\cdot]^\times$ represents the complex conjugate operation, M_{nl} represents the n orders and l heavy moments of input image, and $H_{nl}(r,\theta)$ can be got by multiplying radius component $R_n(r)$ and angle component $e^{il\theta}$. In the formula of PCET, $R_n(r)$ can be got by $R_n(r) = e^{2\pi nr2}$ while the $R_n(r)$ in PCT is $R_n(r) = cos(\pi nr^2)$ and $R_n(r)$ in PST is $R_n(r) = sin(\pi nr^2)$.

2.3. Hausdorff distance theory

For two different sets of points $X = \{x1,x2,\ldots,x_{Nx}\}$and $Y = \{y1,y2,\ldots,y_{Ny}\}$, the definition of Hausdorff distance [10–13] is

$$HD(X, Y) = max\left(d(X, Y), d(Y, X)\right) \tag{3}$$

$$d(X, Y) = \max_{x_i \in X}\min_{y_j \in Y}\|x_i - y_i\| \tag{4}$$

HD stands for the distance of the two different sets of points $X = \{x_1,x_2,\ldots,x_{Nx}\}$ and $Y = \{y_1,y_2,\ldots,y_{Ny}\}$ stands for the directed distance of the two different sets of points $X = \{x_1,x_2,\ldots,x_{Nx}\}$ and $Y = \{y_1,y_2,\ldots,y_{Ny}\}$,the property of the formula is that the