Palmprint Verification: An Implementation of Biometric Technology

Wei Shu
Department of Automation, Tsinghua University,
Beijing, P. R. China
David Zhang
Department of Computer Science, City University of Hong Kong,
Kowloon, Hong Kong

Abstract

As the important implementation of biometric technology, palmprint verification is one of the most reliable personal identification methods. In this paper, a new approach to palmprint verification based on line feature matching and datum point invariance is presented. The datum points of palmprint, which act as the important registrations, are defined owing to their remarkable advantage of invariable location. Then, the simple and efficient methods of line feature extraction and matching are proposed. Several palmprint images are adopted to test the approach and the experimental results show the effectiveness of palmprint verification.

1. Introduction

Palmprint, which has been used as a positive human identifier for more than 100 years, is still considered as one of the most reliable means distinguishing a person from the others due to its stability and uniqueness[1]. However, it is never applied to identify individuals in automatic biometric systems except the shape of a person's hand. In this paper, a new approach to palmprint verification, which can tackle the problems occurring in both fingerprint identification and hand geometry identification, is presented.

The palmprint is made up of principal lines, wrinkles and ridges. In the palmprint, some kinds of features could be listed as geometry features (e.g., width, length and area of a palm), line features (e.g., principal lines, coarse wrinkles and fine wrinkles) and point features (e.g., minutiae and delta points). Palmprint verification, which is to determine whether two palmprints are from the same palm, can use the physical features mentioned above to verify the identity of a live person in principle. However, geometry features are easily captured so that a fake palm could be created, and point features can only be obtained from the fine resolution image. It follows that the palmprint verification will adopt some line features, such as principal lines and coarse wrinkles, as the biometric features.

In addition, a pair of points, ***a*** and ***b***, are derived by the principal lines (life line and heart line) which intersect the both sides of palm (see Fig. 1). Owing to the stability of the principal lines, two points and their midpoint ***o*** remain unchanged day in and day out. Some significant properties can be defined as the following: (1) these points are location invariant in a palmprint; (2) a two-dimensional right angle coordinate system can be uniquely established, of which the origin is the midpoint ***o*** and the main axis passes through these points. As a result, this pair of points and their midpoint will act as the important datum points in the palmprint verification.

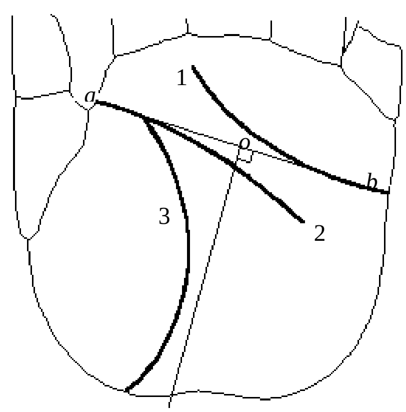

Fig. 1 Definitions of principal line and datum point in a palmprint: principal lines (1 heart line, 2 head line and 3 life line) and datum point (***a*** and ***b*** endpoint, ***o*** the center).

Compared with fingerprint verification which is a point matching process [2], the palmprint verification using the line features and datum points has some effective characteristics: (1) it is based on the image with low spatial resolution so that the size of palmprint image can be reduced, even it is comparable to that of a fingerprint image; (2) significant features in palmprint can be determined in case of the presence of noise because of feature extraction relied on low spatial resolution; (3) palmprint verification, which is a line matching process, can obtain ideal verification accuracy since a line has more information than a point and line matching has several advantages over point matching [3]; (4) the datum points of palmprint are more stable than those of fingerprint.

Therefore, the palmprint verification based on datum point invariance and line feature matching is the important implementation of biometric technology.

2. Line feature extraction and representation

Feature extraction is always an important yet difficult step in image verification. Many line feature detection methods have been proposed, and most of them cannot generate a precise line map of stripe images such as palmprint images. Although the method of pyramid edge detection based on stack filter performs well for these types of lines, it only extracts the principal lines from a palmprint image [4].

It is widely known that some nonlinear filter can be commonly used as a detector for thin vertical lines and it can be extended to detect both lines in directions other than the vertical and thick lines [5]. Nevertheless, many ridges and fine wrinkles have the same width as coarse wrinkles except that they are shorter. As a result, the algorithm mentioned above is also difficult to extract the line features from a palmprint because a mass of ridges and fine wrinkles detected dirty the line features. We improve on this algorithm to extract and post-process line segments of each orientation respectively and then combine them. The improved algorithm consists of the following main steps:

1) Determine vertical line segments by using the five near-vertical patterns [5], and then thin and post-process these line segments. The rule of post-processing is to clear up the segments shorter and in directions other than the vertical.
2) Similarly, detect lines in other three directions.
3) Combine the results of four different directions, and then post-process once more. The goal of post-processing is to eliminate the segments overlapped.

The line features extracted from a pair of palmprint images by the improved algorithm are shown in Fig. 2.

Obviously, line features include curves and straight lines, where the former still consist of several straight line segments. In fact, there are many ways to represent a line. One way, which is always possible, is to store the endpoints of every straight line segment [6].

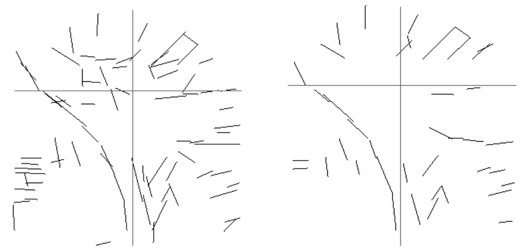

Fig. 2 Linear features extracted from the palmprints.

Let pixel (i, j), where i, j = 0, …, M-1, locate in an $M\times M$ palmprint image. The datum points can be derived as (i_a, j_a), (i_b, j_b) and (i_o, j_o), and an only two-dimensional right angle x-y coordinate system is established by them. The correspondence between the i-j coordinate system and x-y coordinate system is denoted as follows:

$$\begin{cases} x=\cos(\phi-\omega)\sqrt{(i-i_O)^2+(j-j_O)^2} \\ y=\sin(\phi-\omega)\sqrt{(i-i_O)^2+(j-j_O)^2} \end{cases} \quad (1)$$

where $\phi = \mathrm{tg}^{-1}[(j - j_o)/(i - i_o)]$ and $\omega = \mathrm{tg}^{-1}[(j_a - j_b)/(i_a - i_b)]$. In the x-y two-dimensional right angle coordinate system the line segments can be described by endpoints: ($x_1(n)$, $y_1(n)$), ($x_2(n)$, $y_2(n)$), n= 1, …, N, where N is the number of line segments. Without loss of generality, exchange the endpoints of each line segment so that $x_1(n) \le x_2(n)$, n = 1, …, N. If $x_1(n) = x_2(n)$, exchange the endpoints so that $y_1(n) \le y_2(n)$. Three parameters of each line segment, including slope ,intercept and angle of inclination, can be calculated as follows:

$$slope(n) = (y_2(n) - y_1(n)) / (x_2(n) - x_1(n)) \quad (2)$$

$$intercept(n) = y_1(n) - x_1(n) \times slope(n) \quad (3)$$

$$\alpha(n) = \mathrm{tg}^{-1}(slope(n)) \quad (4)$$

3. Line feature matching

The goal of matching is to tell whether two line segments from a couple of palmprint images are the same in a palmprint. The x-y coordinate system does act as the important registration in the line matching. For example, two line segments from two images can be represented as ($x_1(n_1)$, $y_1(n_1)$), ($x_2(n_1)$, $y_2(n_1)$) and ($x_1(n_2)$, $y_1(n_2)$), ($x_2(n_2)$, $y_2(n_2)$), respectively. The Euclidean distances between the endpoints of two line segments are denoted as

$$d_1 = \sqrt{((x_1(n_1) - x_1(n_2))^2 + ((y_1(n_1) - y_1(n_2))^2} \quad (5)$$

$$d_2 = \sqrt{((x_2(n_1) - x_2(n_2))^2 + ((y_2(n_1) - y_2(n_2))^2} \quad (6)$$

In addition, the difference of angle of inclination (difference between two line segments) and that of intercepts are calculated as

$$\varphi = |\alpha(n_1) - \alpha(n_2)| \quad (7)$$

$$\delta = |intercept(n_1) - intercept(n_2)| \quad (8)$$

Without question, the following conditions for line segment matching can be proposed: (1) if both d_1 and d_2 are less than some threshold *D*, then it clearly indicates that two line segments are same; (2) within class of equal angle of inclination and equal intercept, when φ and δ are less than some threshold β and *B* respectively, two line segments clearly belong to the same one if one of d_1 and d_2 is less than *D*; (3) while two line segments overlap, they are regarded as one line segment if the midpoint of one line segment is between two endpoints of another line.

By applying the above line matching rules to a pair of palmprint images, we can obtain the corresponding pairs of lines (shown as Fig. 3). And the verification function, *r*, is defined as

$$r = 2N / (N_1 + N_2) \qquad (9)$$

where *N* is the number of these corresponding pairs; N_1 and N_2 are the numbers of the line segments determined from two palmprint images, respectively. In principle, it shows that two images are from one palm if *r* is more than some threshold *T*.

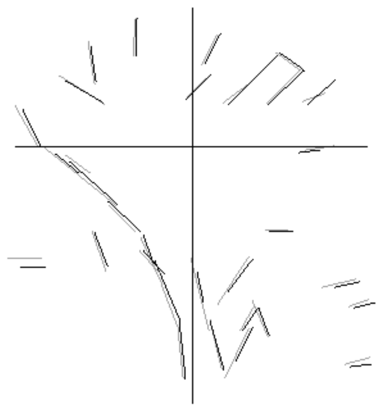

Fig. 3 Matching result of the palmprints in Fig. 2.

4. Experimental results and conclusions

In the experiment, 400×400 gray-scale inked palmprint images are employed. The resolution is 100 dpi, 256 gray levels.

The palmprint verification approach has been tested with the palmprint images, of which 20 couples are from 20 right palms. Some thresholds are adopted as follows: $D = 5$, $\beta = 0.157$ and $B = 10$. The measure of experimental results is represented by a slippery pair of statistics known as false rejection rate (FRR) and false acceptance rate (FAR). The results are shown in Fig. 4 with the various threshold *T*, and palmprint verification can achieve an ideal result while $T = 0.2$.

In this paper, we have implemented an automated biometric-based identification which both datum points and line features extracted from the palmprints are used to verify the identity of a live person. The datum points are defined as points of the registration in palmprint matching because of their stability. An improved algorithm of line feature extraction is also presented due to its simplicity and efficiency. The line features are considered as straight line segments and represented by their endpoints. Several rules are applied to match the line features so as to determine whether a couple of palmprints are from the same palm. 20 couples of palmprint images are determined by using the both datum point invariance and line feature matching and the experimental result shows that the verification accuracy is acceptable and effective.

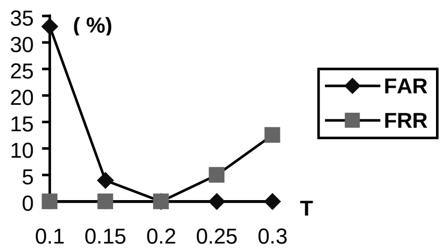

Fig. 4 Experimental results: FAR and FRR.

The proposed approach is also foolproof because these significant physiological features are unique, unchanging, and cannot be forged and transferred. Palmprint verification by using both datum points and line features has the remarkable advantage of requiring lower spatial resolution. As the result, it can limit the size of palmprint image and also be insensitive to noise. As an important complement of automated biometric-based identification, palmprint can be effectively used to identify individual.

References

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