A Texture-based Dynamic Selection Scheme for Palmprint Identification

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Abstract

A key issue in palmprint identification involves the search for the best matching of the sample in the palmprint database. The traditional methods which are based on exhaustive comparison are very time consuming. This paper describes an efficient and dynamic approach to fast comparison for palmprint identification. The concept of texture energy is introduced to define a palmprint's global feature, which is characterized with high convergence of inner-palm similarities and good dispersion of inter-palm discrimination. Such a global feature is used to guide the dynamic selection of a small set of similar candidates from the database for further matching. The experimental results demonstrate the effectiveness and accuracy of the proposed method.

Key words

Palmprint identification, feature extraction, texture features, classification.

1. Introduction

Palmprint identification is one of the biometrics computing approaches to recognize a person from a large group of people. In a palmprint identification system, a person is represented by a set of palmprint features and the recognition process is to compare the newly captured sample against all templates in the database. When the database becomes large, the one-by-one comparison is very time consuming which can hardly meet the requirement for real-time on-line identification. It is essential to develop an effective indexing scheme to lead to quick search and comparison. However, little has been done on the palmprint identification systems.

In order to index the palmprint database, suitable feature should be found first. A feature that can be used as index should exhibit a large variance between individuals and small variance between samples from the same palm. It also should be compact which means small size and comparison effective which means easy to compare.

Palm is the inner surface of a hand between the wrist and the fingers. Palmprint is referred to principle lines, wrinkles and ridges on the palm. There are many features associated with a palmprint such as principle lines, datum points, geometry features, wrinkle features, and minutiae features [1-2]. All these features are based on points and line segments and they are represented in the style of binary point or line map. Though these features can be used to accurately discriminate palmprints [2], they are not suitable for large quantity palmprint database indexing. That is because of the relative big feature size and high computation demand for matching.

Unlike the existing techniques which are concentrate on local attributes such as points and lines, we proposed a texture-based feature extraction method which can describe the global attributes of a palm. These texture-based features can be represented by several numbers, therefore are compact, comparison effective and suitable for palmprint database indexing.

In terms of texture-based global features, some palms are so distinct that they can be easily discriminated from all others while some are so popular that they are similar to a set of palms. Considering of this characteristic, a dynamic selection scheme is introduced to ensure that the palmprint from the same palm won't be missed as well as the smallest candidate set will be given.

The follows of this paper will explain the texture-based feature extraction and dynamic selection scheme in details and experimental results and conclusion will be highlighted in the end.

2. Texture-based feature extraction

2.1. Background

A palmprint consists of various lines with different widths and directions. These lines can be classified into three categories, principle lines, wrinkles and ridges. Principle Lines are three strong major lines named heart line, head line and life line respectively [3]. Wrinkles are thin and irregular lines and curves different from principle lines. Ridges are the tiny regular lines covered the palm skin surface. Different types of lines on a palmprint are shown in Figure 1.

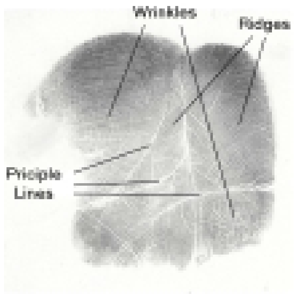
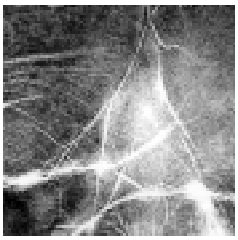


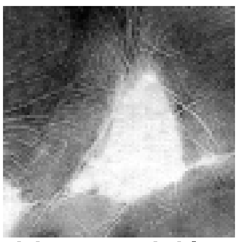
Figure 1. Lines on a palmprint

In general, the pattern of an individual's palmprint is stable and unique. Different people have different palmprint patterns. Figure 2 shows four palmprints with different line patterns.



(a) Strong principle lines

(b) full of small wrinkles



(c) Less wrinkles

(d) Strong wrinkles

Figure 2. Palmprints with different line patterns

In order to measure the similarity of different samples, a reference method is proposed to define the difference between two palmprints in terms of their features. Such features can be well represented by texture because a palmprint consists of large amount of thin and short line segments in forms of wrinkles and ridges. Historically, structural and statistical approaches have been adopted for texture feature extraction [4-6]. The use of statistical texture energy measurement for palmprint feature representation is described as below.

2.2. Palmprint texture and Global texture energy (GTE)

For a palmprint image I of size $n \times n$, the global texture energy is defined as:

$$E_A(I) = \frac{1}{n \times n} \sum_{i=a+1}^{n-a} \sum_{j=a+1}^{n-a} F(i,j) \qquad (1)$$

$$F(i,j) = \left| \sum_{k=-a}^{a} \sum_{l=-a}^{a} (I(i+k, j+l) \times A(k,l)) \right| \qquad (2)$$

where A is the convolution mask for the capture of palmprint texture feature which is shown in Figure 3. The four GTE values are named E_1, E_2, E_3, E_4 respectively. Because the four masks demonstrate the line directional features, the accordingly calculated GTE values may also reflect such features. Particularly E_1 reflects the horizontal line energy, E_2 reflects the vertical line energy, E_3 reflects the 135° line energy and E_4 reflects the 45° line energy.

-1	-2	-4	-2	-1
0	0	0	0	0
2	4	8	4	2
0	0	0	0	0
-1	-2	-4	-2	-1

(a) Horizontal line

-1	0	2	0	-1
-2	0	4	0	-2
-4	0	8	0	-4
-2	0	4	0	-2
-1	0	2	0	-1

(b) Vertical line

2	0	-4	-1	0
0	8	0	-6	-1
-4	0	12	0	-4
-1	-6	0	8	0
0	-1	-4	0	2

(c) 135° angle line

0	-1	-4	0	2
-1	-6	0	8	0
-4	0	12	0	-4
0	8	0	-6	-1
2	0	-4	-1	0

(d) 45° angle line

Figure 3. Four masks used to calculate GTE

These global features have the following characteristics:

a) Insensitive to noise caused by small dirt dot on the palm.
b) Insensitive to shift.
c) Easy to compute.
d) Compact and comparison effective.

3. Dynamic selection scheme

Based on the global palmprint feature GTE, a fast and flexible selection algorithm will lead to a small set of the most similar candidates in the database. As a selection result, palmprints that are far from the being recognized one are excluded and a candidate list is generated. The selection algorithm first calculates the distance between the input sample and every element in the database based on their GTE values. A dynamic selection scheme is then applied which filters out the elements with large difference. Only a small set of the most similar candidates remains for fine matching. Some technical details are summarized as below.

3.1. The concept

Suppose I_i and I_j represent two palmprints and their GTE features are $E_1(I_i)$, $E_2(I_i)$, $E_3(I_i)$, $E_4(I_i)$, $E_1(I_j)$, $E_1(I_j)$, $E_1(I_j)$, $E_1(I_j)$ respectively. The distance $D(I_i, I_j)$ is defined as follows:

$$D(I_i, I_j) = \sum_{k=1}^{4} | E_k(I_i) - E_k(I_j) | \qquad (3)$$

Owning to the shift, rotation, different pressure, different humidity, different stretching degree of fingers, dirtiness and any other unpredictable variance of a palm at different capture time, palmprints captured from the same palm may vary from one another. But the overall look of a palm won't change significantly. So when given a palmprint, all samples from the same palm should be closed to the given one. This characteristic can be noted as follows: For a given I_A, $\forall I_i$ from the same palm as I_A, $D(I_A, I_i) < N$, N is a fixed value. The smaller N is, the better. Experimental results proved this characteristic.

After calculated the GTE features to all palmprints in the database, the dispersion of global features and the average distance between two palms can be given. With any one GTE feature, the range that all palmprints fallen in can be noted as (A, B) and the average distance between two different palms is noted as M. Figure 4 shows the relationship of B, A, M, N visually.

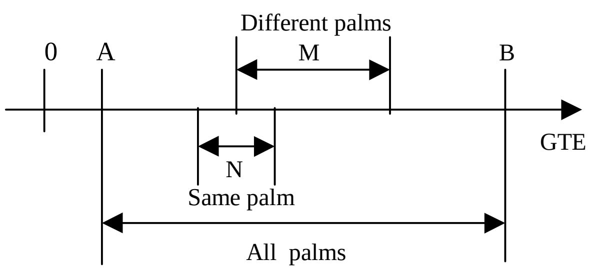


Figure 4. Illustration of A, B, M, N

Based on the four GTE features, four groups of B, A, M, N are calculated, which are denoted as (B_i, A_i, M_i, N_i) $(1 \le i \le 4)$ respectively. It is expected that $| B - A | >> M >> N$. Also the global features of all palmprints from different palms are expected to disperse in the range (A, B) equally. Experimental results show the relationship of B, A, M, N and the dispersion map will be given.

3.2. Implementation

In terms of global GTE feature, some palmprints are so distinct that they can be easily discriminated from others while some are so popular that they are similar to a group of palmprints. Our selection objective is to provide a candidate list with least amount while ensure the expected correct answer won't be missed. In order to achieve this goal, a dynamic selection scheme is developed. It is called dynamic because the selection rules are decided by the being recognized palmprint. The selection process is described as follows:

a) Compare $E_i(I_A)$ with A_i and B_i $(1 \le i \le 4)$ to decide the important sequence of $E_i(I_A)$. The more closed to the boundary of range (A_i, B_i) $E_i(I_A)$ is, the better.

b) Let list R be the result candidate list and at first it includes all palmprints in the database. According to the significance of $E_i(I_A)$, perform four passes of filtering, at the end of each pass check the candidate number in R, if it is less than 10, go to d). The filter rule is as follows: if $| E_i(I_A) - E_i(I_x) | \rangle N_i$, delete I_x from R.

c) Adopt filter rule: if $D(I_A, I_x) > \sum_{k=1}^{4} N_k$, delete I_x from R.

d) Return R as the result.

4. Experimental results

The palmprint collection process is like this: first have the inked palmprint on a white paper and then scan it into the computer and perform a series of preprocessing such as histogram equalization to the scanned images. Only the central part of a palm is used to calculate the GTE features. Totally 100 palms are used and two palmprints from each palm are captured. For inspection to the compactness within one palm, 100 palmprints from one palm are captured. Four types of experiments are conducted. The first is to test whether the GTE is insensitive to shift by shifting a palmprint in different degree. Table 1 shows that GTE is insensitive to tiny shift. The image size is 232×232, unit is pixel. The number in the first row represents horizontal shift offset and the first column represents vertical shift offset. The value in the middle of the table represents the distance between the shifted image and the original image. The average distance between two palms is 51 units.

Table 1. Insensitive to shift

D	-20	-10	0	10	20
-20	4	3	3	1	2
-10	3	1	2	3	2
0	4	1	0	2	2
10	3	3	1	2	3
20	4	2	2	2	2

The second is to verify whether GTE is compact within one palm. The third is to inspect how well GTE disperses among all palmprints in the whole database. Figure 5 shows the GTE is compact within a palm and nearly equally dispersed in the whole database. Only one feature is showed, other three are similar.

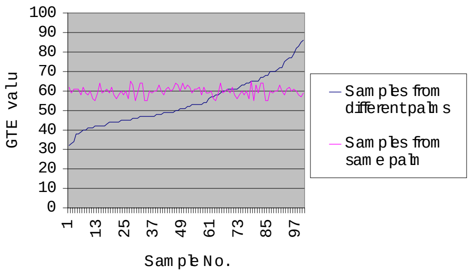


Figure 5. Dispersion of GTE feature

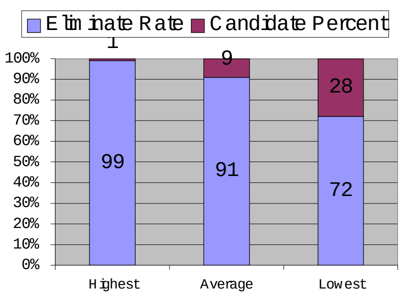


Figure 6. Elimination rate

Finally the efficiency of the texture-based dynamic selection scheme is measured in terms of elimination rate. Figure 6 shows the accuracy and efficiency of the texture-based dynamic selection scheme.

5. Conclusion

Palmprint is regarded as one of the most unique, reliable and stable personal characteristic and palmprint identification provides a powerful means to authenticate individuals for many security systems. In contrast to the traditional local line and point based feature extraction, we proposed a global texture based feature extraction method and developed a dynamic selection scheme for palmprint identification. Our comparative study of palmprint feature extraction shows that palmprint patterns can be well described by textures, and the texture energy measurement possesses a large variance between different classes while remaining high compactness within the class. A flexible selection scheme based on the global texture features provides a simple way to quickly exclude most of the candidates in the database. The experimental results provides the basis for further development of a fully automatic palmprint-based security system with high performance in terms of effectiveness, accuracy, robustness and efficiency.

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