Automated personal identification by palmprint

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Abstract. We present a palmprint approach to identifying individuals. Some significant features covering both geometrical and structural characteristics can be extracted from the palmprint to distinguish a person from others. The experiments show that this approach can be effectively used as a new biometric technology for automated personal identification.
[S0091-3286(98)01908-4]

Subject terms: personal identification; palmprint; biometrics; pattern recognition.

Paper 09117 received Nov. 12, 1997; revised manuscript received Feb. 19, 1998; accepted for publication Feb. 19, 1998.

1 Introduction

Automated biometric-based identification means verifying or recognizing the identity of a live person on the basis of some physical or behavioral characteristics. There have been two current approaches—fingerprint identification and hand geometry identification—in personal identification that are based on the measurement and comparison of the features extracted from the person's hand.[1,2] Fingerprint identification is the most widespread application of biometrics technology, where some small unique features (known as minutiae) are used to build the corresponding eigenspace. However, it is still a difficult task to detect the minutiae from the fingers of elderly people and manual laborers.[3] For hand identification with the three-dimensional shape, one could fool the system by capturing a person's hand geometry and creating a fake hand.[1]

Palmprint identification can tackle these problems because it deals with relatively stable physical characteristics, basically unalterable without trauma to the individual.[4] This means that many useful features, besides those extracted from both fingerprint and hand shape, can be simultaneously obtained from a palmprint. However, they have never been applied to identify individuals in biometric systems, except for the shape of the hand. Therefore, it is necessary to develop a new approach to automated personal identification by palmprint.

2 Notation and Definitions

In a palmprint (see Fig. 1), there are three principal lines, called as the lines of the life, heart, and head. They are unique and unchanging, and cannot be forged. In addition, two end points, a and b, can be obtained from the intersections of principal lines with the two sides of the palm. Because of the stability of the principal lines, the end points and their midpoint o remain unchanged from year to year. Some significant properties can be observed as follows: (1) the locations of the endpoints and their midpoint are rotation-invariant; (2) a two-dimensional rectangular coordinate system can be established uniquely, of which the origin is the midpoint o and the x axis passes through the endpoints; (3) the size of a palm can also be uniquely specified by the Euclidean distance between two end points together with the length of their perpendicular bisector in the palm (segment cd in Fig. 2); (4) a palm can be divided into three regions (finger-root region, inside region, and outside region) by the line segment connecting the end points and its perpendicular bisector. As a result, the endpoints and their midpoint can serve as registrations for automatic matching because of their invariable locations.

3 Palmprint Features

There is rich and useful information in a palmprint. Some kinds of features are as follows:

(1) *Geometry features:* According to the palm's shape, we can extract the corresponding geometry features, such as width, length, and area, which can be easily detected.
(2) *Principal-line Features:* Both location and form of principal lines in a palmprint are very important physiological characteristics to identify an individual, because they vary little from time to time.
(3) *Wrinkle features:* In a palmprint, there are many wrinkles, which are different from the principal

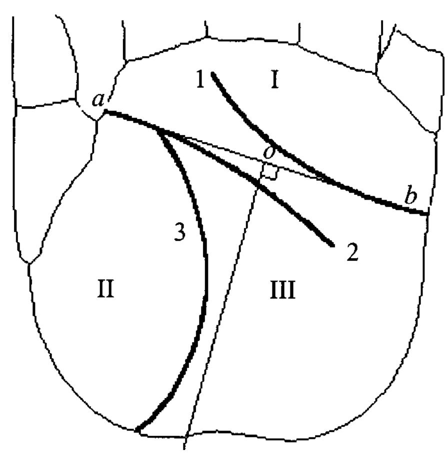

Fig. 1 Definitions for a palmprint: principal lines (1, heart line; 2, head line; 3, life line), regions (I, finger-root region; II, inside region; III, outside region), end points (*a* and *b*), and their midpoint (*o*).

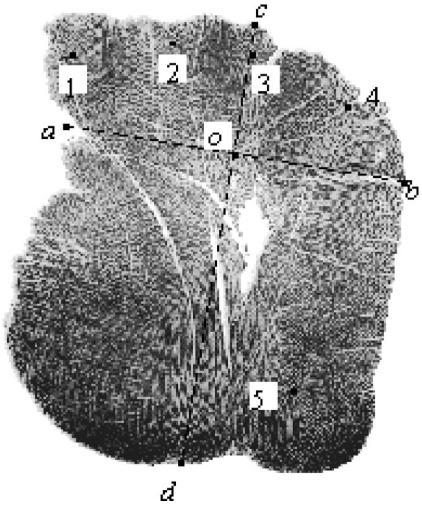

Fig. 2 Geometry features and delta-point features of a palmprint, where *cd* is the perpendicular bisector of segment *ab* and points 1 to 5 are delta points.

Fig. 4 Directional image of a palmprint (different gray levels represent different directions, and the center of each white circle corresponds with a delta point shown in Fig. 2).

lines in that they are thinner and more irregular, so more detailed features can be obtained.

(4) *Delta-point features:* A delta point is defined as the center of a delta-like region in the palmprint.[5] It is known that there always are some delta points located in the finger-root region and the outside region (e.g., points 1 to 5 in Fig. 2). This makes it possible to acquire these features and establish their stability and uniqueness.

(5) *Minutiae features:* A palmprint is basically composed of ridges; hence the minutiae can be used to extract stable and unique features.

In principle, the features mentioned above can be determined from palmprint images with fine resolution and used for identification.

4 Feature Extraction

In general, geometry features, principal-line features, and wrinkle features can be obtained from a low-resolution image, even a low-quality one. As delta points can be effectively located in a directional image,[5,6] delta-point features can be extracted from a fine-resolution palmprint image even in the presence of noise. However, minutiae can be detected only from the high-quality and fine-resolution images. For example, the minutiae in a small region of a palmprint and a directional image produced from Fig. 2 are shown in Fig. 3 and Fig. 4, respectively. In Fig. 4, the delta points correspond with the pixels around which there are at least three directions. The spatial resolution of these palmprint images is 400 dots per inch (dpi). Some principal-line features can also be extracted from an image whose resolution is 100 dpi (see Fig. 5).

Obviously, principal-line features have the advantage of requiring lower spatial resolution, so that the palmprint image can be smaller and the system is less sensitive to noise. Some significant features that can be detected from palm-

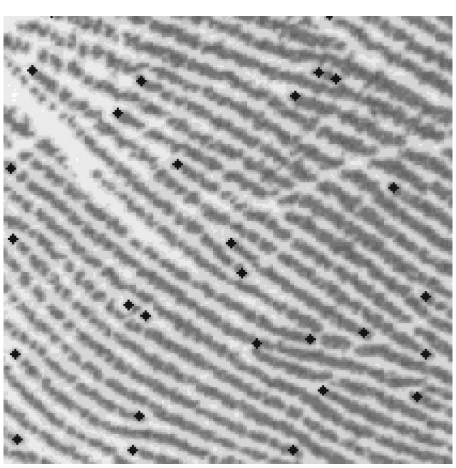

Fig. 3 A small region of a palmprint and the minutiae extracted from it.

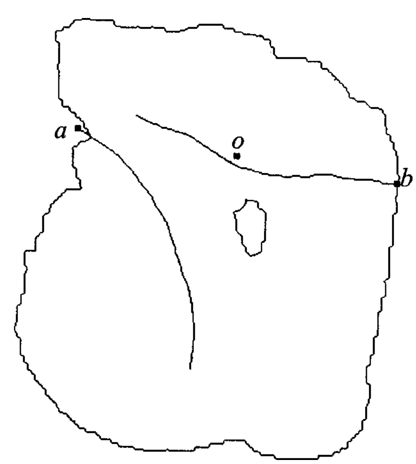

Fig. 5 Some principal-line features determined from the palmprint image with low spatial resolution.

Table 1 The FRR and FAR using the different features in the palmprint. F_1: geometry features; F_2: eight points on the principal lines; F_3: twelve points on the principal lines; F_4: F_1 and F_2; F_5: F_1 and F_3.

	Value (%)									
	F_1		F_2		F_3		F_4		F_5	
Threshold	FRR	FAR	FRR	FAR	FRR	FAR	FRR	FAR	FRR	FAR
T_0	0	11.1	0	0.8	0	0.7	0	0.2	0	0
T_1	13	8.2	8	0.7	4	0.5	8	0.2		
T_2	31	4.7	33	0.2	8	0.2	33	0.2		
T_3	71	1.9	46	0.2	21	0.1	46	0.2		
T_4	100	0	46	0	31	0	46	0	0	0

print images with low spatial resolution are as follows: First the geometry features width and length as defined in Fig. 2, are obtained easily once the pair of end points, a and b, are located. Second, several points on the principal lines can be detected to describe the structural properties of the principal lines. Here, the points with the distances of nl ($n=1,2,...,N$) from the point a are chosen on the life line, where l is a distance parameter and N is the number of points. In the same way, the points on the heart line are located by the distances between them and the point b.

5 Experimental Results

An identification parameter, r_{ij}, can be calculated as

$$r_{ij}=1-\sum_{k=1}^{n} w(k)\,\frac{|f_i^k-f_j^k|}{|f_i^k+f_j^k|}, \tag{1}$$

where n is the number of features; the weight $w(k)$ is between 0 and 1 ($k=1,...,n$), and $\Sigma_{k=1}^{n} w(k)=1$; f_i^k and f_j^k are the kth features of sample i and j, respectively. In addition, the measure of acceptance or rejection is defined as

$$I_{ij}=\begin{cases}1 & \text{if } r_{ij}\geqslant T \ \text{(accept)},\\ 0 & \text{otherwise (reject)},\end{cases} \tag{2}$$

where T is a threshold.

Three experiments based on different features are performed, where five thresholds are named T_i ($i=0,1,...,4$). T_0 (T_4) is the minimum (maximum) r_{ij} of the same (different) palmprint(s), and $T_i=T_0+i(T_4-T_0)/4$ ($i=1,2,3$; $T_4>T_0$). The weights $w(k)$ are obtained from experience. The geometry features are used to verify the palmprint images in the first experiment. Next, the principal-line features are acquired, and the Euclidean distance between each point and the midpoint o is calculated as the feature. Eight or twelve points are chosen to represent principal-line features. In the third experiment, we use a multistep identification method, where geometrical features are compared to eliminate some palmprints when the threshold is not more than T_0 and principal-line features are employed to process the remaining palmprints for fine-level matching.

The measure of the experimental result is provided by a subtle pair of statistics known as the false-rejection rate (FRR) and false-acceptance rate (FAR). The FRR (FAR) is the number of false rejections (acceptances) divided by the number of prints the same (different) palm(s).

All experiments were conducted on a database containing 48 pairs of prints the same palm and 844 pairs of prints of different palms. The experimental results shown in Table 1 are three sets of FARs and FRRs obtained by using different features. They show that the identification accuracy is acceptable when twelve points on the principal lines are applied in the multistep identification. Obviously, the experiment with the multistep identification feature is better than the others, and the more features are used, the better we meet the demand for personal identification.

6 Conclusions

As a new attempt at biometric-based authentication, in this paper, we have explored automated palmprint identification as an approach to countering some insufficiencies in fingerprint and hand identification. In principle, the proposed approach is both foolproof and convenient, because many significant physiological characteristics, which are unique, unchanging and easily extracted, can be employed to identify individuals. Some features have been extracted to test the effectiveness of this approach, and the preliminary results suggest that palmprints can be effectively applied to identity verification. The technique works well in the presence of noise in the palmprint image, because the features adopted can be obtained from a low-resolution image. More effective features, such as delta points and minutiae, can be gained when both the resolution and the quality of the palmprint image are high. It is believed that this approach can have practical application to automated personal identification as a new biometric technology.

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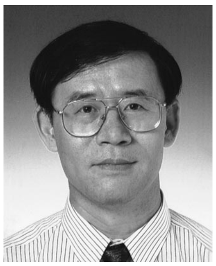

David Zhang graduated in computer science from Peking University in 1974 and received his MSc and PhD degrees in computer science and engineering from Harbin Institute of Technology (HIT) in 1983 and 1985, respectively. From 1986 to 1988 he was a postdoctoral fellow at Tsinghua University, and he became an associate professor at Academia Sinica, Beijing, China. In 1988, he joined the University of Windsor, Ontario, Canada, as a visiting research fellow in electrical engineering. He received his second PhD, in electrical and computer engineering, at the University of Waterloo, Ontario, Canada, in 1994. Currently, he is an associate professor in City University of Hong Kong. His research areas include automated biometric-based identification, neural systems and applications, VLSI system design methodology, and parallel computer architecture. He has authored and coauthored nearly 100 papers and two books, and has received several project awards. Dr. Zhang is a senior member of the IEEE.