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Palm Print Identification Using Zernike Moments

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Abstract*— Hand geometry contains relatively invariant features of an individual. Palm print recognition is an efficient biometric solution for authentication system. The existence of several hand-based authentication commercial systems indicates the effectiveness of this type of biometric. Moments are the most commonly used technique in character feature extraction. The idea of implementing orthogonal moments as palmprint feature extractors is prompted by the fact that principal features of both character and palmprint are based on line structure. These orthogonal moments are able to define statistical and geometrical features containing line structure information about palmprint. Experimental results show that the performance of the system is dependent on the moment order. The orthogonal property of these moments is able to characterize independent features of the palmprint image and thus have minimum information redundancy in a moment set. Zernike moments of order of 7 have the best performance among all the moments. Its identification rate is 85.00%, which also represents the overall performance of this palmprint identification system.

Index Terms—**Biometrics, Moments, Palmprint, Zernike**

I. INTRODUCTION

Palm print authentication is one of the relatively new physiological biometric technologies which exploit the unique features on the human palmprint, namely principle lines, wrinkles, ridges, datum points, etc. The rich texture information of palmprint offers the effective means in person authentication due to its non-intrusive, user friendly, stable, low-resolution imaging and low cost requirements [3]. This has drawn considerable interest and attention to researchers especially from academia. An important issue in palmprint recognition is to extract palmprint features that can discriminate an individual from the other. There are two popular approaches to palmprint recognition. One of the approaches is to transform palmprint images into specific transformation domains. Another approach is to extract principal lines and creases from the palm. However, this method is not easy because it is sometimes difficult to extract the line structures that can discriminate every individual well. Besides, creases and ridges of the palm are always crossing and overlapping each other, which complicates the feature extraction task. Chinese character is similar to palmprint, which is also constructed from the line structures, and moments have been utilized for shape extraction for long time [Wu02a]. Moment can describe Chinese character uniquely regardless how close the characters are in terms of local features. This inspired us to implement the moments function to extract the palmprint ridges and creases for the human identification tasks. In this paper, we had implemented Zernike moments (ZM) as feature descriptors in the application of human palmprint identification. These approaches are able to provide adequate information about different types of statistical and geometrical information of the creases and ridges in the palmprint image. Orthogonal basis of the moments can attain a zero value of redundancy measure in a set of moment functions, so that these orthogonal moments correspond to independent characteristics of the image. In other words, minimum information redundancy in a moment set is obtained. Moments' geometrical invariance promote themselves as commonly used feature extraction approaches in a broad spectrum of applications in image analysis, such as invariant pattern recognition, reconstruction, object classification and etc.

II. PALMPRINT PRE-PROCESSING

In the palmprint acquisition stage, users are allowed to place their palms freely on the platform of the scanner when scanning is performed. Therefore, palmprint images captured in the image acquisition stage may have variable size and orientation and also subject to noise. Moreover, the region of not-interest (e.g. fingers, wrist, image background, etc.) may affect accurate processing and degrade the verification performance. Therefore, image pre-processing is a crucial and necessary part before feature extraction. In this study, the region of interest (ROI) is extracted from the palmprint images. The ROI in this paper is defined in a square shape after the correction of orientation. Then the ROI is converted to a fixed size (150 x 150 pixels) so that all of the palm prints conform to a same size [4].

III. ZERNIKE MOMENTS

The kernel of Zernike moments is a set of orthogonal Zernike polynomials defined over the polar coordinate space inside a unit circle[2]. The two dimensional Zernike moments of order p with repetition q of an image intensity function f(r,θ) are defined as:

$$Z_{pq} = \frac{p+1}{\pi}\int_0^{2\pi}\int_0^{1} V_{pq}(r,\theta)\, f(r,\theta)\, r\, dr d\theta \; ; \; |r| \leq 1 \qquad \text{…….. (1)}$$

where Zernike polynomials $V_{pq}(r,\theta)$ are defined as:

$$V_{pq}(r,\theta) = R_{pq}(r)\, e^{-jq\theta};\; j = \sqrt{-1} \qquad \text{……………………..(2)}$$

and the real-valued radial polynomials, $R_{pq}(r)$, is defined as follows:

$$R_{pq}(r) = \sum_{k=0}^{\frac{p-|q|}{2}} (-1)^k \frac{(p-1)!}{k!\left(\frac{p+|q|}{2}-k\right)!\left(\frac{p-|q|}{2}-k\right)!} r^{p-2k} \qquad \text{………...(3)}$$

where $0 \leq |q| \leq p$ and $p - |q|$ is even.

If N is the number of pixels along each axis of the image, then the discrete approximation of equation

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(1) is given as:

$$Z_{pq} = \lambda(p,N) \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} R_{pq}(r_{ij})\, e^{-jq\theta} f(i,j); \quad \ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

$$0 \le r_{ij} \le 1$$

where λ(p,N) is normalizing constant and image coordinate transformation to the interior of the unit circle is given by

$$r_{ij} = \sqrt{x_i^2 + y_j^2}\ ;$$

$$\theta = \tan^{-1}\left(\frac{y_j}{x_i}\right);$$

x = c i + c ;
y = c j + c ;

Since it is easier to work with real functions, Z_{pq} is often split into its real and imaginary parts, Z^c_{pq}, Z^s_{pq}

$$Z^c_{pq} = \frac{2(p+1)}{\pi}\int_0^{2\pi}\int_0^1 R_{pq}(r)\cos(q\theta) f(r,\theta) r\, dr d\theta\ ; \quad \ldots\ldots\ldots.(5)$$

$$Z^s_{pq} = \frac{2(p+1)}{\pi}\int_0^{2\pi}\int_0^1 R_{pq}(r)\sin(q\theta) f(r,\theta) r\, dr d\theta\ ; \quad \ldots\ldots\ldots.(6)$$

where p ≥ 0 , q > 0 .

For the implementation, square image (N x N) is transformed and normalized over a unit circle;

i.e. x2+y2 ≤1 , which the transformed unit circle image is bounding the square image. Figure shows

the square-to-circular transformation. In this transformation,

$$\lambda(p,N) = \frac{4(p+1)}{(N-1)^2\pi};$$

$$c_1 = \frac{\sqrt{2}}{N-1};\ c_2 = \frac{-1}{\sqrt{2}};$$

$$x_i = \frac{\sqrt{2}}{N-1} i + \frac{-1}{\sqrt{2}} \text{ and } y_j = \frac{\sqrt{2}}{N-1} j + \frac{-1}{\sqrt{2}}$$

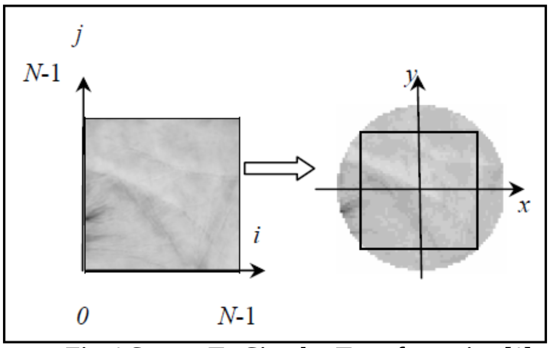

Fig. 1 Square To Circular Transformation [1]

IV. PALMPRINT VERIFICATION BASED ON ORTHOGONAL MOMENT'S FEATURES

A palm print verification system is a one-to-one matching process. It matches a person's claimed identity to enrolled pattern. There are two phases in the system: enrolment and verification. Both phases comprise two sub-modules: pre-processing for palmprint localization, enhancement and feature extraction for moment features extraction. However, verification phase consists of an additional sub module, classification, for calculating dissimilarity matching of the palmprint. Figure 5 shows the palmprint verification system block diagram. At the enrolment stage, a set of the template images represented by moment features is labelled and stored into a database. At the verification stage, an input image is converted into a set of moment features, and then is matched with the claimant's palmprint image, based on the ID, stored in the database to gain the dissimilarity measure by computing Euclidean distance metric. We used this distance metric instead of more complex classification algorithm (e.g. neural network) because we were just focusing on the feature extracting rather than the classification. Finally, the dissimilarity measure is compared to a predefined threshold to determine whether a claimant should be accepted. If the dissimilarity measure below the predefined threshold value, the palmprint input is verified possessing same identity as the claimed identity template and the claimant is accepted.

V. EXPERIMENTAL RESULTS

Experiments were conducted by using a set of database consisting of 20 different classes of palm prints. Each hand has 10 palm print images. 7 from each is used for training the system, total 140 images. And other 3 images were used for testing purpose, total 60 images. At the first stage, database was used and experiment was conducted using different settings of feature vectors based on the order of ZM and the efficiency is calculated by Euclidean distance is shown in Table 1.

Table 1:

MOMENT ORDERS	EFFICIENCY(%)
0,1	68.3333
0,1,2,3	81.6666
0,1,2,3,4,5	78.3333
0,1,2,3,4,5,6,7	85.0000
0,1,2,3,4,5,6,7,8,9	71.6666
0,1,2,3,4,5,6,7,8,9,10,11	65.0000
0,1,2,3,4,5,6,7,8,9,10,11,12, 13	70.0000
0,1,2,3,4,5,6,7,8,9,10,11,12, 13,14,15	61.6666

The 7th order gives the maximum efficiency of 85%. The other results are then shown are of this moment order. In identification, a palm image has been compared to N palm images. For our particular case, three palm image for each palm; is reserved as the test image to be stored in the database. Remaining palm images are used as test images to be identified. Therefore; there are 7 template and 3 test images for each palm. There are totally 140 templates and 60 test images. Each test image is compared to all templates in the database, and the test image is matched with the most similar template, that is the template generating the smallest matching score. Figure 2 displays the histogram of the smallest distance, the distance between the test images and the most similar templates, for correct matches. Figure 3 shows the histogram of the second smallest distance, the distance between the test images and the second most similar templates. It is here worth noting that the difference between the smallest distance and the second smallest distance gives an idea about the reliability of the identification; that is the bigger the difference is, the more reliable the identification is. Let the reliability of identification ratio, RI, be defined as the ratio of this difference to the smallest distance, as in Equation (7). The histogram of the reliability of identification ratio is

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depicted in Figure 4.

$$RI = \frac{\text{smallest distance}}{\text{second smallest distace} - \text{smallest distance}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

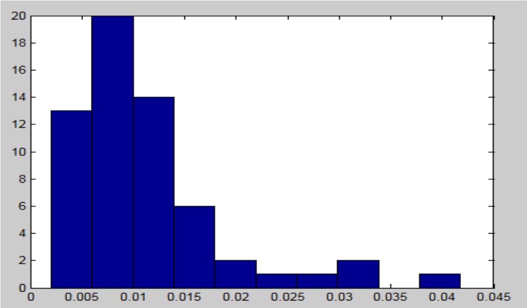

Fig.2 smallest distance histogram

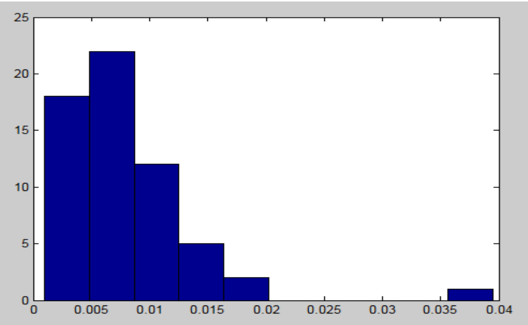

Fig.3 second smallest distance histogram

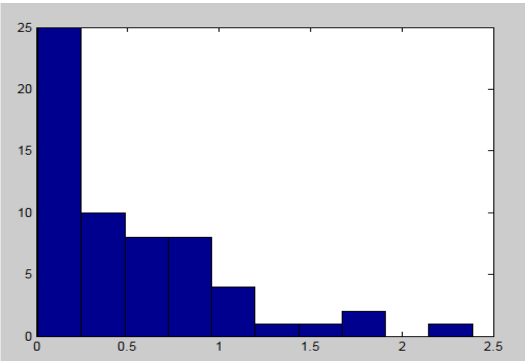

Fig.4 reliability of identification

VI. CONCLUSION

The performance of Zernike moments palmprint authentication system was presented in this paper. The Zernike moments of order 7 has the best performance among all the moments. Its efficiency is 85%, which represents the overall performance of this palmprint authentication system. The proposed algorithms, orthogonal moments, possess some advantages: orthogonality and geometrical invariance. Thus, they are able to minimize information redundancy as well as increase the discrimination power.

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