Principal Component Analysis based Palmprint Recognition with Center of Mass Moments

R.Vivekanandam, M. Madheswaran

Abstract - Palmprint is one of the relatively new physiological biometrics due to its stable and unique characteristics. The rich feature information of palm print offers one of the powerful means in personal recognition. Palmprint Region Of Interest (ROI) segmentation and feature extraction are two important issues in palmprint recognition. This paper introduces two steps center of mass moment method for ROI segmentation and Principal Component Analysis (PCA) for obtaining palmprint feature vector and matching is done by Hausdroff Distance method(HD). The recognition rates are unexpectedly improved compared to the classic approach. Experiment results show that this system can achieve a high performance.

Index Terms - Center of mass moment, Centroid, Palmprint, Hausdroff distance, Human identification, Principal Component Analysis, Region Of Interest.

1. INTRODUCTION

Human identification becomes an important and highly demanded technique for security access systems in modern identification and verification systems[1],[2]. For fingerprint and iris pattern where high-resolution images are required (e.g. over 400 dpi). A palm print is essentially the large inner surface of the hand. It possesses certain discernable and unique characteristics, which can be easily extricated using Palm print Capture Devices. These devices provide us with an image called a friction ridge impression[3]. The impression can then be checked for the unique characteristics which include principal lines, ridges, minutiae points, singular points and texture[4]. Palmprints are unique between people and relatively low-resolution images will suffice (less than 100 dpi)[5].
One key feature in palm print identification is deciding how the image is to be taken for identification purposes. The images taken generally involve the entire hand of the subject. The problem with using the entire hand is that the area of the hand except for the palm can also be included in the identification process. In some cases, this may lead to obfuscation of the image and thus, may lead to faulty identification. One way to resolve this issue is by cropping the entire image to give that area of the image which contains the palm itself. This area is termed the ROI. The main problem in palmprint recognition system is how to extract the ROI and the features of palmprint.

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A solution widely followed to reduce the area of palm sample is to select a square region by using a universally accepted reference point that is key points. One such reference point being used is parallel line drawn below the base of fingers to extract ROI[5]. There were many works about ROI segmentation such as: J.Doublet[6],[7],[9], proposed a system that uses color information and neural network model for hand detection; uses shape information and Active Shape Model(ASM) for key points detection. Xiaoxu[9], developed some key points between hand fingers to generate the ROI. Ivan Fratric[7], described a Real-Time Model-Based hand Localization and Viola-Jones approach was used for hand candidate detection.

During hand localization phase, a large number of hand models were used for matching the candidate. Ong[10], designed a touch-less palmprint verification system, which use Gaussian model for hand segmentation and a novel method to find hand key points. Michal Choras[11], used skin threshold for hand segmentation and though these approaches[10],[11] are very concise, they may not work in cluster background. Yufei Han et al[12], used two parallel placed web cameras for ROI acquisition. Principal Components' coefficients, which is resulted from projection of data space onto the feature space determined by PCA, can be used for feature extraction as a compressed description (feature set) to approximate the data space at some statistical accuracy. This paper proposed a better method called two steps in central mass moment to extract the ROI with PCA and HD for palmprint identification.

2. DIFFERENT STAGES

Palm print verification employs either high or low resolution images. Most of the research on palmprint

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verification uses the low resolution images[5],[13]. The palmprint verification system consists of four stages: Palmprint image acquisition, preprocessing, feature extraction and matching as shown in Fig. 1. The palmprint image is acquired using a palmprint scanner or digital camera. Preprocessing has two parts, image alignment and ROI selection.

Image alignment is done by referring to the key points. Region of Interest selection is the cropping of palmprint image from the hand image. Feature extraction obtains discriminating features from the preprocessed palmprints. The matching compares the captured image features with the stored templates.

3.PREPROCESSING

Preprocessing is used to correct distortions, align different palmprints, and to crop the ROI for feature extraction. Research on preprocessing commonly focuses on following steps Binarizing and boundary tracking the palm images, Identification of key points, Establishing a coordination system and Extracting the central part(ROI).

3.1 Two steps center of mass moment method

Extracting the central part that is the ROI is one of important factor for recognition performance. This paper proposed a better technique to extract the ROI is called two steps in central moment method. The steps of the method can be explained as follows: **i).** The gray level hand image is threshold to obtain the binary hand image. The threshold value is computed automatically using the Otsu method. To avoid the white pixels (not pixel object) outside of the hand object is used median filter.

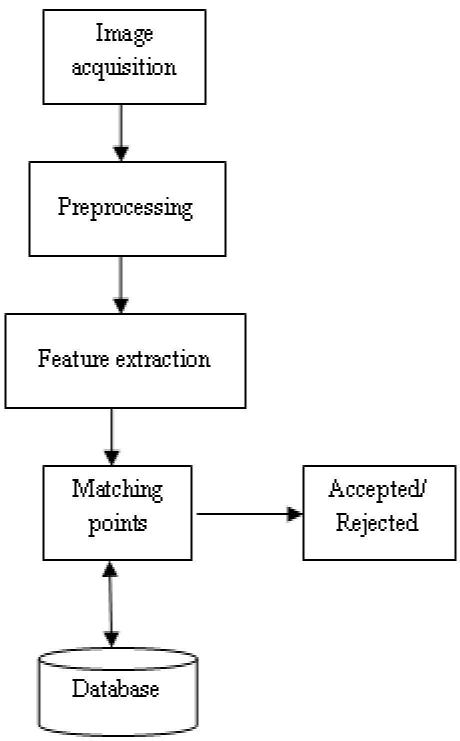


Fig 1. Flow graph of matching process for palmprints

ii). Each of the acquired hand images needs to be aligned in a preferred direction so as to capture the same features for matching. The moment orientation method is applied to the binary image to estimate the orientation of the hand. In the method, the angle of rotation (θ) the difference between normal axis and major axis of ellipse that can be computed as follows.

$$\theta = \frac{1}{2} tan^{-1} \left| \frac{2\mu_{1,1}}{\mu_{2,0}-\mu_{0,2}} \right| \qquad (1)$$

$$\mu_{p,q} = \sum_m \sum_n (m-\bar{m})^p (n-\bar{n})^q \qquad (2)$$

where $\mu_{p,q}$ represent the $(p,q)^{th}$ moment central, and $((\bar{m}-\bar{n})$ represents center of area is defined as

$$\bar{m} = \frac{1}{N}\sum_m \sum_n m \quad , \quad \bar{n} = \frac{1}{N}\sum_m \sum_n n \qquad (3)$$

where *N* represent number of pixel object. Furthermore, the grayscale and the binary image are rotated about (θ) degree.

iii). Bounding box operation is applied to the rotated binary image to get the smallest rectangle which contains the binary hand image. The original hand image, binarized-bounded image are shown in Fig 2. (a) and (b). **iv)**. The centroid of bounded image is computed using equation (3) and based on this centroid, the bounded binary and original images are segmented with 200x200 pixels. The segmented image and its centroid position are shown in Fig 2. (c) and (d). **v)**. The centroid of the segmented binary image is computed and based on this centroid the ROI of grayscale palmprint image can be cropped with size 128x128 pixels. The first and the second positions of centroid in binary and gray level image are shown in Fig 2. (e) and (f). This method has been tested for 200 palmprint images, and the results show this method is reliable.

4. FEATURE EXTRACTION AND MATCHING

For any type of biometric recognition, the most important task is to extract distinguishing features from the template data, which directly dictates the recognition accuracy. After preprocessing of palmprint images, features can be extracted for matches. There are two types of recognition algorithms, verification and identification. In verification, the system validates a person's identity by comparing the captured biometric data with her own biometric templates stored in the system database.

Verification is typically used for positive recognition, where the aim is to prevent multiple people from using the same identity. In identification, the system recognizes an individual by searching the templates of all the users in the database for a match. Identification algorithms must be accurate and fast. Research on feature extraction and matching methods can be classified into four categories: line-based, subspace based, statistical-based and coding based. PCA comes under Sub space based method also called appearance based approach.

4.1 Principal Component Analysis

Principal Component Analysis (PCA) [14], is one of the so-called appearance-based methods, which operate directly on an image-based representation and extract features in the subspace derived from the training images. PCA is commonly used for both palmprint[15], and face recognition [16]. The central idea of PCA is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. That is a PCA used to transform the data from an original, high dimensional space into a feature space with significantly fewer dimensions.

A PCA constructs the projection axes (which define the feature space with lower dimensionality) based on the training samples of the users taken from the original space. After that, one or more samples from the training set are projected onto these axes to obtain the feature vectors that represent the users' template(s), to be stored in a database. These templates are used in the matching process with the users' test templates. The stored templates can also be treated as enrolled users' templates and they are used for matching with the users' live templates during the authentication phase.

The sample covariance matrix (an unbiased estimator for the covariance matrix of x) is given by

$$S = \frac{1}{n-1} X'X \qquad (4)$$

where X is a (n × p) matrix with $(i,j)^{th}$ element $(x_{ij} - \bar{x}_j)$ (in other words, X is a zero mean design matrix). Construct the matrix A by combining the p eigenvectors of S (or eigenvectors of $X'X$) then the matrix PC scores can be defined as Z=XA, otherwise instead of Z by select the q eigenvectors corresponding to the q largest eigenvalues of S when forming A then it can be can achieved an optimal q-dimensional projection of x.

After finding the sample covariance matrix $S = \frac{1}{n-1} X'X$ the most straightforward way of computing the PCA loading matrix is to utilize the singular value decomposition of $S = A\Lambda A$ where A is a matrix consisting of the eigenvectors of S and Λ is a diagonal matrix whose diagonal elements are the eigenvalues corresponding to each eigenvector. Creating a reduced dimensionality projection of X is accomplished by selecting the q largest eigenvalues in Λ and retaining the q corresponding eigenvectors from A.

4.2 Hausdroff Distance

In order to describe clearly the matching process, Hausdroff distance is used. The HD is the maximum distance of a set to the nearest point in the other set. Distance from set A to set B is a maxim in function, defined as

$$H(A,B) = \max\{h(A,B), h(B,A)\} \qquad (5)$$

Line Segment Hausdroff Distance (LHD) extends the concept to two sets of line segments, LHD is built on the distance (d(m, r)) between two line segments m and t, which is defined as

$$d(m,t) = \sqrt{d_\theta^2(m,t) + d_i^2(m,t) + d_l^2(m,t)} \qquad (6)$$

In the above equation, $d_\theta = \min(l_m - l_t) \times \sin(\theta(m,t))$ where, l, and i, denote the lengths of m and t, and $\theta(m,t)$ represents the smallest interesting angle between m and i. Curve Segment Hausdroff Distance (CHD) measures the dissimilarity between two shapes based on the distances between two sets of curve segments.

RESULT AND DISCUSSION

5.1 Database

The database contains 200 palmprint images captured from 200 hands corresponding to 100 individuals. The volunteers are college students or staff and are all Indians. Twenty of them are girls, taken only left hand images, and most of them are 22-25 years old. The acquisition of the remaining 180 images is done on two separate sessions from 90 males in the ages ranging from 21 to 50 years.

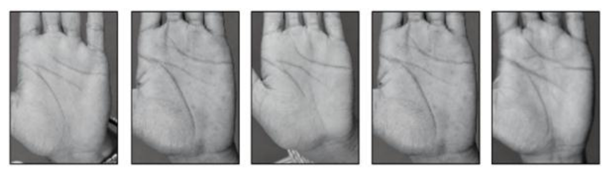


Fig 1. Hand Images of 5 different

The average time interval between the two occasions is 7 days. Two samples are collected from each subject from his left palms in one session and right palms in another. Fig.3 Shows the left hand palmprint images of five different male persons

5.2 Performance Comparison

The performance of the proposed two steps center of mass moment method is compared with three methods namely circle generated from the center of limits and concentric circular bands method, key point coordinate system and fixed-size square blocks with PCA and HD. After comparison, recognition accuracy obtained using the proposed method along with the other methods is listed in Table 1. It is evident from the Fig 5 and table that the recognition accuracy of the proposed method is comparatively higher than those obtained by the other methods. The performance of the proposed method is also very satisfactory for the given database (for both left hand and right hand palmprint images). An overall recognition accuracy of 99.94% is achieved.

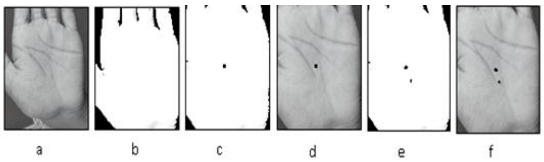


Fig 2. a) Extracted original image b) Bounded binary image c) Binary image with first centroid d) Gray level image with first centroid e) Binary image with second centroid f) Gray level image

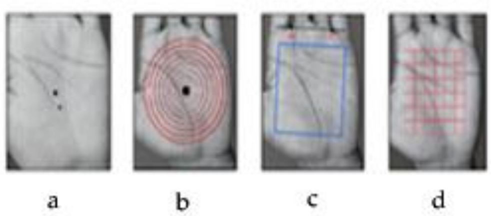
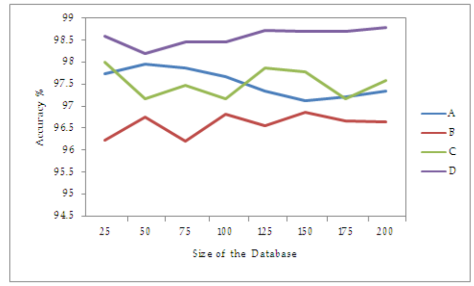


Fig 4. a) The proposed two steps center of mass moment method b) Concentric circular bands method c) Key points coordinate system method d) Fixed-size square blocks method.

Table 1. Percentage of Accuracy for various methods for ROI with PCA and HD

Database Size	Matching Accuracy (%)			
	Concentric circular bands	Key point coordinate	Fixed Size Sq. Blocks	Center of mass moment(proposed)
25	97.7475	96.2234	98.0021	98.5850
50	97.9649	96.7471	97.1568	98.1862
75	97.8649	96.1936	97.4575	98.4596
100	97.6803	96.8098	97.1584	98.4545
125	97.3290	96.5611	97.8741	98.7040
150	97.1165	96.8641	97.7865	98.6897
175	97.2098	96.6572	97.1655	98.6901
200	97.3465	96.6345	97.5794	98.7810



A. Fixed-size square blocks B. Non-overlapping elliptical half-rings C. Key points coordinate system D. Two steps center of mass moment method

Fig 5. Variation of accuracy with size of the database for different methods

CONCLUSION

The proposed method - a two steps center of mass moment method for ROI selection of palmprint with PCA and hausdroff distance - method shows the best identification results among the several compared methods without sacrificing the verification accuracy. Results are promising with accuracy as high as 98.781% for testing in a database of 200 subjects at palmprint recognition. Even when only 50 images were used, the level of accuracy can still be retained at 98.5850%. The experiment result also show that the performance of this system relatively stable although the database size is increased.

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