Palmprint recognition using Contourlet Transform Energy Features

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***Abstract* – Palmprint recognition is an accepted and widely used biometric. Richness of feature and the less cost involved in acquisition make it more reliable and user friendly. The region of interest is extracted from the palmprint image as a preprocessing step. Contourlet transform, a pyramidal directional filter bank is then applied to capture both local and global details of the palmprint. The large number of coefficients generated from the contourlet transform are minimised as a dimensionality reduction process, by calculating energies for each subband. Palmprint matching is then performed using nearest neighbor classifier.**

Keywords: *Biometrics, Palmprint, ROI Extraction, Feature Extraction, Contourlet Transform, Zernike moments*

I. INTRODUCTION

In our daily life, it is routine that we are asked for our identity verification. It is done by using several measures like passwords, ID cards, personal identification number(PIN) etc., In this connection the personal identification and verification is becoming important today. Because of increased forgery and identity impersonation, the traditional way of authentication is not sufficient[9]. Biometrics provide a new way of efficient authentication at low cost, which is not only better than the current methods, at the same time provides a convenience way of having nothing to carry or remember. This makes biometrics an emerging field of research in the recent days. Although there are numerous distinguishing traits such as iris or retinal scanning, face recognition, fingerprints, or voices used for personal identification, this research focusses on using palmprints to more accurately and efficiently identify different personnel through classification at a low cost.

The central part of palm contains three flexion creases, secondary creases and ridges. The flexion creases are otherwise called principal lines and the secondary creases as wrinkles. These flexion and the major secondary creases are formed between the 3rd and 5th months of pregnancy [1] and superficial lines appear after we born. Even though the three major flexions are genetically dependent, most of other creases are not [2]. Even identical twins have different palmprints. These non-genetically deterministic and complex patterns are very useful in personal identification. Palmprint research is carried out by using either high resolution or low resolution images. High resolution images are used for forensic applications such as criminal detection [3]. Low resolution images are more suitable for civil and commercial applications such as access control. In general high resolution refers to 400 dpi or more and low resolution refers to 150 dpi or less. Researchers can extract ridges, singular points and minutia points as features from high resolution images while in low resolution images they generally extract principal lines, wrinkles and texture. Initially palmprint research focused on high-resolution images [4][5] but recent research is on low resolution images for civil and commercial applications.

The acquisition of palmprint is carried out by using scanners, low cost CCD camera or digital camera. These captured images are subjected preprocessing, feature extraction, template extraction as well as matching with the database.

In this work, a new method is introduced to extract the region of interest from the palmprint. The Contourlet transform is applied to extract features. Energies are calculated for each subband as feature selection process. The nearest neighbour classifier is used to determine the final biometric classification. The remaining of this paper is organised as follows. Section II details Literature Survey, Section III Palmprint Preprocessing. In Section IV Feature extraction & Selection. Experimental Study in Section V, Conclusion in Section VI and finally References are in Section VII.

II. LITERATURE SURVEY

Palmprint recognition is carried out in [12] by extracting the edges from the palm images and then performing the Contourlet Transform (CT) or the Discrete Wavelet Transform (DWT) on the edge extracted images. The sub-band images are divided into M*M non-overlapping blocks. The energy of each block is calculated and normalized to form a feature vector. Then principal component analysis PCA is employed where the approximation images are input to it for dimensionality reduction and to produce the eigen palms.

Palmprint based authentication [13] is presented by extracting the Region of interest (ROI) from the palmprint image by finding a tangent of curves between fingers. The perpendicular bisector of this tangent divides the rectangular area enclosing the palmprint into two equal parts. The features extracted from the ROIs are used for matching. Two approaches are suggested for the feature extraction. In the first approach the ROI is divided into a suitable number of non-overlapping windows from which fuzzy features are extracted. In the second approach multi-scale wavelet decomposition is applied on the ROI and the detail images are combined to yield a superimposed image which is partitioned into non-overlapping windows. From these windows energy feature is extracted. The two sets features are used to determine the genuine and impostor scores.

Multimodal biometric recognition system based on non-subsampled contourlet transform (NSCT) proposed in [15] to improve the recognition rate of the singlemodal biometric system and to solve the small samples recognition problem, based on pixel level fusion. All image samples are normalized and decomposed using nonsubsampled contourlet transform. Then the normalized nonsubsampled contourlet-transformed face and palm print features at the pixel fusion level are combined. KNN classifiers are used to determine the final biometric classification. Experiments were conducted using CVL database and PolyU palm print database.

Palmprint nonlinear discriminant feature extraction and recognition is proposed in [16] by using a kernel discriminant analysis based on NSCT and palm recognition method. NSCT transformation is applied to palm images and new palm images were obtained with multiresolution and multidirectional. Then mapping the palm images to the kernel space, according to the kernel discriminant capacity to choose the new palm images with high discriminant capacities and used them to extract the discriminant features.

In our proposed system, Region of Interest(ROI) is extracted by employing new methodology which can extract the desired portion of the palm from the image irrespective of its different orientations. Contourlet Tranform is applied to extract the high dimensional features, which is enormously present in the palmprint. Contourlet transform decomposes the input image into many subbands. Energy features are calculated as a feature selection step and feature vector is created.

III.PALMPRINT PREPROCESSING

Pre-processing is essential for selecting necessary features and to improve the performance. Normally there are two ways of acquiring peg free palmprint images. One is by capturing the image using palmprint capturing devices, or by taking images by using low resolution digital camera with dark background. In both cases, there is a possibility of slightly rotational or translational differences in capturing various images in various times. Therefore, palmprint images captured in the image acquisition stage may have different orientation and size and also subject to noise. Moreover, the region of not-interest (e.g fingers, wrist, image background, etc) may affect the accuracy in processing and verification performance. Therefore, image pre-processing is necessary before feature extraction. Therefore a new method of rotating the image to the desired position and then extracting ROI is proposed. In the ROI extraction phase, the region of interest (ROI) is extracted from the palmprint images by using a following methodology.

1. Select the palmprint image.

2. Find the threshold level to convert the grayscale image into binary image by using canny edge detection. Threshold level is a normalized intensity value that lies in the range [0, 1].

   $g(x, y) = 0$ if $f(x, y) < T$ or 1 if $f(x, y) \geq T$

3. For each connected component in the binary image, measure the regions.

4. Find the centroid for all the regions. The centroids are shown in Fig 1(a).

5. Calculate the distance between each centroids.
   d_{mn}, $m \neq n$

Centroid of the points $(x_1, y_1),(x_2, y_2) \ldots(x_n, y_n)$ is

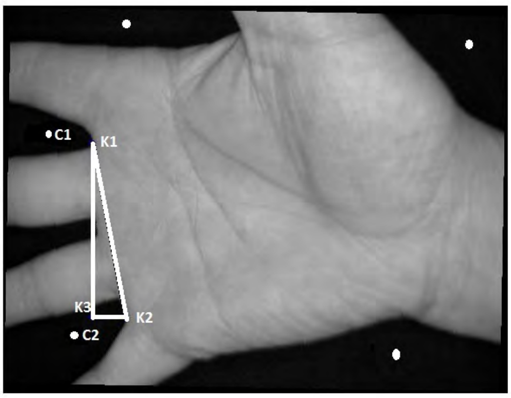
$$\frac{x_1 + x_2 + \ldots\ldots\ldots x_n}{n}, \frac{y_1 + y_2 + \ldots\ldots\ldots y_n}{n}$$

6. Find the least two distances among all. In Fig.1(b), the least distances are d_{13} and d_{23}. For any palmprint this will be true due to the image capturing setup.

7. Eliminate the common centroid C3 and Mark the other two centroids as C1 and C2.

8. From the C1 and C2 traverse to the right to find the finger joint and mark these points as K1 and K2. The distance transform chessboard distance metric is used. This measures the path between the pixels based on an 8-connected neighbourhood. Pixels whose edges or corners touch are 1 unit apart. The longest distance is considered as the finger joint.

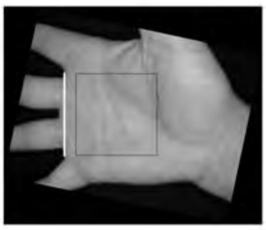
9. Draw a tangent line between K1 and K2. Draw a right angle triangle as this tangent as one side. the third point is K3. After calculating the angle, align the tangent to Y axis. Crop the ROI of size 128 X 128from this reference line as shown in Fig 1(d).



(a)

(b)

(c)



(d)

(e)

Fig 1. Preprocessing and Extraction of ROI

IV FEATURE EXTRACTION & SELECTION

As shown in Fig.2., the contourlet features are extracted from the palmprint ROI. The contourlet Transform is a directional transform, which is capable of capturing contours and fine details in images. The contourlet expansion is composed of basis function oriented at various directions in multiple scales, with flexible aspect ratios. With this rich set of basis functions, the contourlet transform effectively captures smooth contours that are the dominant feature in palmprint images[17]. In contourlet transform, the Laplacian pyramid does the decomposition of images into subbands and then the directional filter banks analyze each detail image as illustrated in Fig. 2

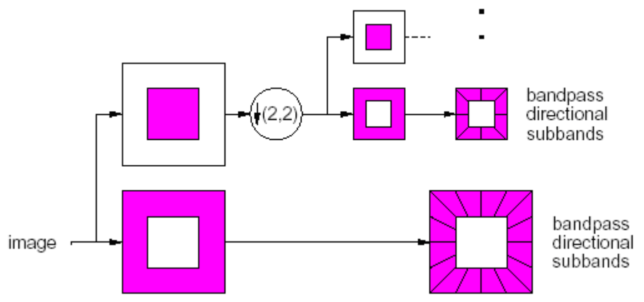


Fig. 2 Contourlet Model

It is proposed by Minh Do and Martin Vetterli and provides sparse representation at both spatial and directional resolutions [18]. Additionally, a flexible multiresolution and directional decomposition by allowing different number of directions at each scale with flexible aspect ratio is offered. The double filter bank structure comprising the Laplacian pyramid capturing the point discontinuities followed by a directional filter bank to link point discontinuities into linear structure. The contourlet transform satisfies the anisotropy scaling relation for curves by doubling the number of directions at every finer scale of the pyramid[19].

Since the contourlet transform has desirable properties for invariant palmprint recognition, it is used to extract features to recognize the unknown palmprint images. In a 3 level decomposition, 8 subbands are generated. The large number of coefficients generated from this need not be involved in the classification step to reduce the computation time. Moreover, it is not true that classification accuracy will improve with increasing number of features. in this work, feature dimension is reduced by calculating the following energy features from each subband.

E1 – Mean

E2 – Standard deviation

E3 – Absolute Mean Energy

E4 – Energy

E5 – Skewness

E4 – Kurtosis

$$E1(s,k) = \mu(s,k) = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} W_{s,k}(i,j)$$

$$E2(s,k)=\sigma(s,k)=\left[\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|W_{s,k}(i,j)-\mu_{s,k}\right|\right]^{1/2} \quad E3(s,k)=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|W_{s,k}(i,j)\right|$$

$$E4(s,k)=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|W_{s,k}(i,j)\right|^{2}$$

$$E5(s,k)=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{\left(W_{s,k}(i,j)-\mu(s,k)\right)^{3}}{\sigma(s,k)^{3}}$$

$$E6(s,k)=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{\left(W_{s,k}(i,j)-\mu(s,k)\right)^{4}}{\sigma(s,k)^{3}}$$

M and N denote the number of rows and columns of the subband image, and s and k denote the index of scale and direction. W is the coefficient of row M and column N in sub-band indexed by s and k, μ and σ represent mean and standard deviation, respectively [25]. Likewise, each computed energy value can be used as an element to form a feature vector, which is denoted as the energy feature vector. The energy features were adopted in this study merely for comparison purpose. Achieving higher recognition rate using short feature vectors is desired[26][27]. It is essential to make a compromise between classification accuracy and the length of feature vectors.

V.EXPERIMENTAL STUDY

Experiments are conducted by using CASIA Palmprint Image Database which contains 5,502 palmprint images captured from 312 subjects. For each subject, the palmprint images are collected from both left and right palms. All palmprint images are 8 bit gray-level JPEG files. Here for our experiment purpose right hand images of 100 subjects are used. The training and test data sets were prepared according to the "leave-one-out" strategy [8]. Then one of the sampled blocks was used as the test sample, and the remaining blocks were used as training samples. 7 images are used for training and 1 for testing. The "leave-one-out" strategy avoided biases that might otherwise be introduced into the results due to inappropriate data sampling. A new methodology is used to extract ROI. The ROI is resized to 128 X 128 to maintain uniformity in image inputs for further work. After extracting the ROI, the three levels of contourlet transform is applied to extract the features. Since
the features are in larger number, energies are calculated for each subband image. A feature vector is formed by using

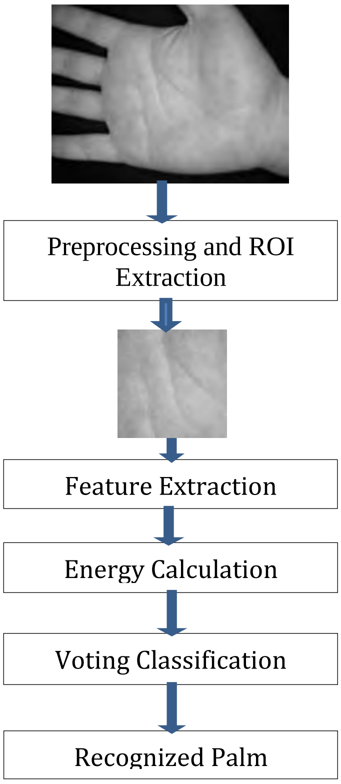


Fig 3. Palmprint recognition methodology

these computed energy value. Thus the vast number of contourlet coefficients are reduced in greater dimension. Each subband is compared with the corresponding subband by simple nearest neighbour classifier. Among eight subbands of each image, the majority voting scheme is followed for classification. The classification accuracy is achieved in this method is 99.0 which clearly shows the proposed method improves classification accuracy and reduces computation time.

VI.CONCLUSION

In this paper, a new technique is developed to extract ROI. After extracting the ROI, the three levels of contourlet transform a pyramidal directional filter bank is applied. Since the features are in larger number, energies are calculated for each subband as feature selection process. Here each subband will have 6 values and the image will have only 48 values. Our idea here is focused on ROI Extraction Feature extraction method rather than Classification. The results are very much promising when Contourlet transform is combined with Energy Calculations and accuracy 99.0% is achieved.

Table 1. Comparision of Methods

Method	Duta et. al [18]	Lie Zhang et. al[19]	G.Y.Chen et. Al[3]	Proposed Method
Database Size	30 images (3 palms)	600 images (100 palms)	600 images (100 palm)	800 (100 palm)
Feature Extraction	Feature points	Feature palms	Feature palms	Feature palms
Feature type	Structural feature	Wavelet Features	Wavelet Features	Contourlet + energy featuresy
Image resolution	400 X 300	128 X 128	128 X 128	128 X 128
Accuracy rate	95.00%	99.2 %	99.0 %	99.0 %

VII.REFERENCES

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