A Novel Pre-processing Technique for DCT-domain Palm-print Recognition

Hafiz Imtiaz, Shubhra Aich, Shaikh Anowarul Fattah

Abstract— In this paper, a novel pre-processing algorithm is introduced to identify the principal lines from a palm-print image and a discrete cosine transform (DCT) domain feature extraction algorithm is then employed for palm-print recognition, which can efficiently capture the spatial variations in the principal lines of a palm-print image. The entire image is segmented into several small spatial modules. The task of feature extraction is carried out in local zones using two dimensional discrete cosine transform (2D-DCT). The proposed dominant DCT-domain feature selection algorithm offers an advantage of very low feature dimension and it is capable of capturing precisely the detail variations within the palm-print image. It is shown that because of the pre-processing step, the discriminating capabilities of the proposed features are enhanced, which results in a very high within-class compactness and between-class separability of the extracted features. From our extensive experimentations on different palm-print databases, it is found that the performance of the proposed method in terms of recognition accuracy and computational complexity is superior to that of some of the recent methods.

Index Terms— Spectral feature extraction, binary palm image, two-dimensional discrete cosine transform, classification, palm- print recognition, entropy, modularization.

---

1. Introduction

CONVENTIONAL ID card and password based identification methods, although very popular, are no more reliable as before because of the use of several advanced techniques of forgery and password-hacking. As an alternative, biometrics, such as palm-print, finger-print, face and iris being used for authentication and criminal identification [1]. The main advantage of biometrics is that these are not prone to theft and loss, and do not rely on the memory of their users. Moreover, they do not change significantly over time and it is difficult for a person to alter own physiological biometric or imitate that of other person's. Among different biometrics, in security applications with a scope of collecting digital identity, the palm-prints are recently getting more attention among researchers [2]. Palm-print recognition methods are based on extracting unique major and minor line structures that remain stable throughout the lifetime. In this regard, generally, either line- based or texture-based feature extraction algorithms are employed [3]. In the line-based schemes, generally, different edge detection methods are used to extract palm lines (principal lines, wrinkles, ridges, etc.) [4], [5].

- *Hafiz Imtiaz is currently an Assistant Professor with the Department of Electrical and Electronic Engineering in Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh. E-mail: hafizimtiaz@eee.buet.ac.bd*
- Shubhra Aich is *currently an undergraduate student with the Department of Electrical and Electronic Engineering in Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh.*
- *Shaikh A. Fattah is currently an Associate Professor with the Department of Electrical and Electronic Engineering in Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh. E-mail: fattah@eee.buet.ac.bd*

The extracted edges, either directly or being represented in other formats, are used for template matching. In cases where more than one person possess similar principal lines, line based algorithms may result in ambiguous identification. In order to overcome this limitation, the texture-based feature extraction schemes can be used, where the variations existing in either the differ- ent blocks of images or the features extracted from those blocks are computed [6]-[8]. Given the extracted features, various classifiers, such as decision-based neural networks and Euclidean distance based classifier, are employed for palm- print recognition [4], [5]. Despite many relatively successful attempts to implement face or palm-print recognition system, a single approach, which combines accuracy, robustness, and low computational burden, is yet to be developed. The objective of this paper is to identify the principal lines from a palm-print image and extract precisely spatial variations from each local zone of the entire palm-print image instead of concentrating on a single global variation pattern. In the proposed palm-print recognition scheme, the entire palm-print image of a person is segmented into several small modules. An efficient feature extraction scheme using 2D-DCT, which offers an ease of implementation in practical applications, is developed, which operates within those local zones to extract dominant spectral features. In comparison to the discrete Fourier transform, the DCT is used as it can efficiently handle the phase unwrapping problem and offer energy compactness as well as computational advantages. It is shown that the discriminating capabilities of the proposed features, that are extracted from the sub-images, are enhanced because of the pre-processing step and also for the modularization of the palm-print image. Finally, recognition task is carried out using a distance based classifier.

2 Pre-Processing

A key issue to be solved for successful palm-print recognition is preprocessing of the palm-print image to gain a proper subarea for feature extraction and classification. Due to the images obtained by a digital scanner without any constraint of pegs, distortions including rotation, shift and translation may be present in the palm images, which make it hard to locate at correct position in the same direction. However, in this research, we intend to employ a pre-processing step to identify the major lines from a palm-print image and extract features from the resultant binary image.

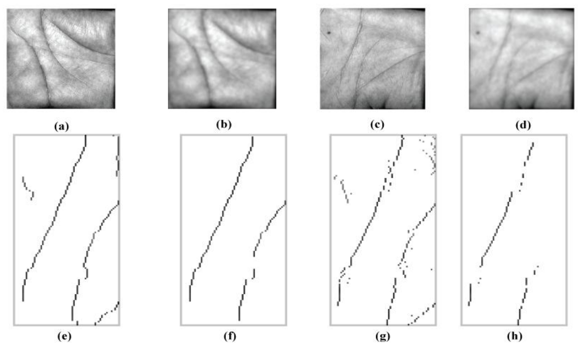

Fig. 1. (a) and (c) show raw palm-print images of two different persons;(b) and (d) show corresponding filtered versions; (e) and (g) show the extracted continuous lines from the filtered and un-filtered image in (b) and (d) respectively; (f) and (h) show the identified major lines from (e) and (g)

2.1 Extracting Major Lines

The major palm-lines in palm-print images can be used to distinguish between different individuals [1], [2]. We intend to extract features from only the major lines of a palm-image, which will reduce the computational complexity by a great deal in the feature extraction step. In order to identify only the major lines from a palm image, first, only the center portion of the palm-print image is extracted from the raw images omitting the black background portion as well as those consisting the fingers. The cropped portion is then filtered using a simple 2D low pass filter (2D-LPF). The low-pass filtering is performed to blur the image, i.e., to reduce the effect of the minors. It affects the majors but since the major lines are much thicker than the minor ones and also most of the unwanted minors are narrow, using a low-pass filter greatly reduces the unwanted minors but affects the majors only slightly. In Figs. 1(a)-(d), palm-print images after cropping are shown along with their filtered versions. Our objective is to check whether it were possible to find out the trajectory of the major lines of the palm-print image since the minors are much more vulnerable to aging than the majors. Furthermore, two or three major lines are the most-prominent in general. Therefore, the cropped palm-print image is segmented into two or more smaller horizontal portions so that the minors become even smaller than before and can be easily eliminated in the trajectory-tracing step. Since, projection search is used to extract the trajectory of the majors, slight rotation does not affect the major line extraction much. Finally, from the selected low intensity pixels, searching for some continuous or quasi-continuous pattern of the major lines using the nonlinear placement of an arbitrary mask and replacing the pixel values outside the patterns with the same high values accomplishes the juxtaposition of the subdivisions.

3 Feature Extraction

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. In comparison to person recognition based on face or voice biometrics, palm-print recognition is very challenging even for a human being. For the case of palm-print recognition, obtaining a significant feature space with respect to the spatial variation in a palm-print image is very crucial. In what follows, we are going to demonstrate the proposed feature extraction algorithm for palm-print recognition, where spatial domain local variation is extracted from frequency domain transform.

3.1 Proposed Spectral Feature

For biometric recognition, feature extraction can be carried out using mainly two approaches, namely, the spatial domain approach and the frequency domain approach [2]. Phenomena, such as rotation, scale and illumination, are more severe in the spatial domain than in frequency domain. Hence, in what follows, we intend to describe a feature extraction algorithm based on frequency domain transformation. It is well-known that Fourier transform based palm-print recognition algorithms involve complex computations. In contrast, discrete cosine transform (DCT) of real data avoids complex arithmetic and offers ease of implementation in practical applications. Moreover, DCT can efficiently handle the phase unwrapping problem and exhibits a strong energy compaction property, i.e., most of the signal information tends to be concentrated in a few low-frequency components of the DCT. Hence, we intend to employ an efficient feature extraction scheme using 2D-DCT. Several palm-print images of different persons have been investigated and it is observed that there exist some correspondences between palm-print features on the spatial domain image and those on the corresponding frequency domain transform. In general, the stronger the majors are on the spatial domain image, the less compact the information is on the frequency domain transform. And if a palm-print image in the spatial domain has a strong line, in the frequency domain there will be more information in the line's perpendicular direction [7]. It has been shown in [7] that the effect of rotation and illumination variation is lower in the DCT-domain than that in the spatial domain. Therefore, for the purpose of feature extraction, 2D-DCT is employed.

3.2 Proposed Dominant Spectral Feature Selection

It can be observed that within a particular palm-print image, the change in information over the entire image may not be properly captured if the DCT operation is performed upon the image as a whole, because of the difference in patterns and positions of major lines. Even if it is performed, it may offer spectral features with very low between-class separation [7]. In order to obtain high within-class compactness as well as high between-class separability, we propose to segment the palm-print image into some small segments, which are capable of extracting variations in image geometry locally. It has been shown in [7] that the entropy calculated from the entire palm-print image is lower by orders of magnitude than the total average entropy of the same palm-print image calculated from all the segments of the image. This clearly gives an indication that, for feature extraction, instead of considering the entire image as a whole, modularization would be a better choice.

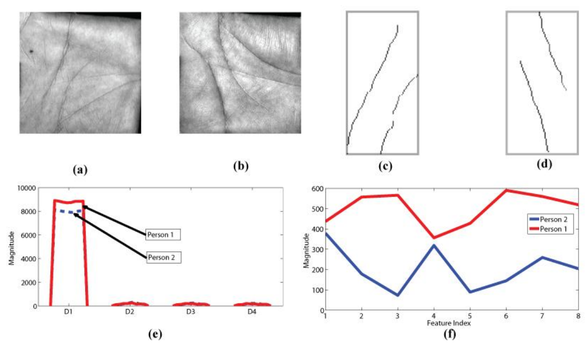

Fig. 2. (a)-(b) Sample palm-print images of two persons; (c)-(d) cor- responding binary palm-print images; (e) proposed dominant magnitude- features corresponding to palm-prints shown in (c) and (d); (f) variation of dominant features with segments for several palm-print images of two persons corresponding to (a) and (b)

Therefore, instead of taking the DCT coefficients of the entire image, the DCT coefficients obtained form each module of an image are considered to form a feature vector. However, if all of these coefficients were used, it would definitely result in a feature vector with a very large dimension. One advantage of working in the DCT domain is that, because of its energy compaction property, a few DCT coefficients with higher magnitudes would be sufficient to represent a portion of an image. Hence, in view of reducing the feature dimension, the magnitudes and 2D-frequencies corresponding to the dominant DCT coefficients as spectral features are proposed to be utilized [7]. In order to demonstrate the characteristics of the dominant magnitudes in different modules, sample palm-print images of two different persons are shown in Fig. 2(a)-(b) and their corresponding binary palm-print images are shown in 2(c)-(d). In 2(e), four dominant magnitudes (D1, D2, D3, and D4) obtained from all the modules of the sample palm-print image of Person 1 appeared in Fig. 2(c) are shown. In this figure, the sample palm-print image (of size 150 × 150 pixels) is divided into 30 segments and from each segments, the four aforementioned dominant magnitudes are computed and shown for the two different persons. It is found that different dominant magnitudes obtained from the spatial modules exhibit different characteristics. However, the magnitude value for the first dominant (D1) is found reasonably higher than other dominant magnitudes. An analogous behavior is obtained for Person 2 of Fig. 2(b). It is evident from Fig. 2(e) that D1 is the most significant among all the dominant magnitudes and thus, it is sufficient to consider only D1 as a desired feature, which also offers an advantage of reduced feature dimension. Computing D1 and the corresponding 2D-frequencies (ω_x and ω_y) in each segment of the binary palm-print image, the proposed feature vector is obtained. For a palm-print image of dimension $N \times N$ with M number of segments (with dimension $n \times n$), considering only D1 will reduce the length of feature vector from $M \times n \times n$ to M, an order of n^2 reduction. It is observed that a significant variation may occur in the palm-print images of a single person taken under different conditions, most notably, rotation and translation. In view of demonstrating the effect of such variations on the proposed dominant features, we consider five sample palm-prints for each of the two persons as appeared in Fig. 2(a)-(b). In Fig. 2(f), the proposed dominant features obtained from different segments of all the sample binary palm-prints of two different persons are shown. For each person, the centroid of the proposed feature vectors is also shown in the figure (in thick continuous lines). It is to be noted that the feature centroids of the two different persons are well-separated even though the major lines of the two palm-print images are quite similar considering the pattern and position. It is also observed that a low degree of scattering exists among the features around their corresponding centroids. Hence, the dominant features extracted locally within a palm-print image offer not only a high degree of between-class separability but also a satisfactory within-class compactness. For the purpose of recognition using the extracted dominant features, a distance-based similarity measure is utilized [7]. The recognition task is carried out based on the distances of the feature vectors of the training palm-images from the feature vector of the test palm-image.

4 Experimental Results

Extensive simulations are carried out in order to demonstrate the effectiveness of the proposed method of palm-print recognition using the palm-print images of several well-known databases. Different analyses showing the effectiveness of the proposed feature extraction algorithm have been shown. The performance of the proposed method in terms of recognition accuracy is obtained and compared with those of some recent methods [8], [9] considering two standard databases, namely, the PolyU palm-print database (version 2) (available at http://www4.comp.polyu.edu.hk/□biometrics/) and the IITD palm-print database (available at http://web.iitd.ac.in/□ajaykr/ Database_Palm.htm).

4.1 Performance Comparison

In the proposed method, dominant DCT-domain features obtained from all the modules of a palm-print image are used to form the feature vector of that image. The recognition task is carried out using a simple Euclidean distance based classifier. The experiments were performed following the leave-one-out cross validation rule. For simulation purposes, the module size for the PolyU database and the IITD database has been chosen as 20 × 20 pixels and 15 × 15 pixels, respectively. For the purpose of comparison, recognition accuracy obtained using the proposed method along with those reported in [8] and [9] are listed in Table I. It is evident from the 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 IITD database (for both left hand and right hand palm-print images). An overall recognition accuracy of 99.94% is achieved. As mentioned earlier, dominant spectral features are extracted from the small modules of the palm-print images. Next, we intend to demonstrate the effect of variation of module width upon the recognition accuracy obtained by the proposed method. In Fig. 3, the recognition accuracies obtained for different module sizes are shown. It is observed from the figure that better recognition accuracies are achieved for smaller segments, which is an indication that variations in the image geometry and intensity, i.e., variations in local information are captured more successfully in case of smaller sized segments. Note that, in case of considering the entire image as a whole instead of any modularization, the recognition accuracy drastically falls to a value less than 17% for both the databases, as expected.

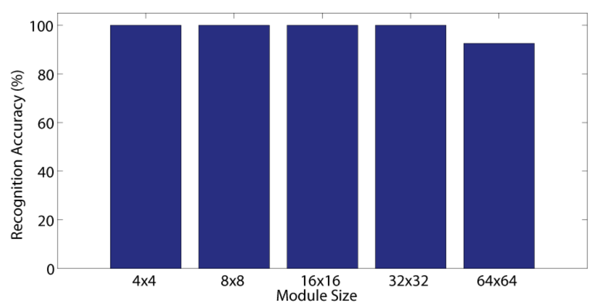

Fig. 3. Variation of recognition accuracy with module size for the PolyU database

5 Conclusion

In the proposed palm-print recognition scheme, instead of operating on the entire palm-print image at a time, dominant spectral features are extracted from binary palm-print images consisting only two/three major lines. It has been shown that because of the novel pre-processing step and the modularization of the palm-print image, the proposed dominant spectral features, that are extracted from the sub-images, attain better discriminating capabilities. The effect of variation of module size upon recognition performance has been investigated and found that the recognition accuracy does not depend on the module size unless it is extremely large. The proposed feature extraction scheme is shown to offer two-fold advantages. First, it can precisely capture local variations that exist in the major lines of palm-print images, which plays an important role in discriminating different persons. Second, it utilizes a very low dimensional feature space for the recognition task, which ensures lower computational burden. For the task of classification, an Euclidean distance based classifier has been employed and it is found that, because of the quality of the extracted features, such a simple classifier can provide a very satisfactory recognition performance and there is no need to employ any complicated classifier. From our extensive simulations on different standard palm-print databases, it has been observed that the proposed method, in comparison to some of the recent methods, provides excellent recognition performance.

TABLE 1
Comparison of Recognition Accuracies

Method	PolyU database
Proposed method	99.96%
Method [8]	97.50%
Method [9]	98.00%

Acknowledgment

The authors would like to express their sincere gratitude towards the authorities of the Department of Electrical and Electronic Engineering and Bangladesh University of Engineering and Technology (BUET) for providing constant support throughout this research work.

References

[1] A. Jain, A. Ross, and S. Prabhakar, “An introduction to biometric recognition,” IEEE Trans. Circuits and Systems for Video Technology, vol. 14, no. 1, pp. 4 – 20, 2004.

[2] A. Kong, D. Zhang, and M. Kamel, “A survey of palmprint recognition,” Pattern Recognition, vol. 42, pp. 1408–1418, 2009.

[3] X. Wu, D. Zhang, and K. Wang, “Palm line extraction and matching for personal authentication,” IEEE Trans. Systems, Man and Cybernetics, Part A: Systems and Humans, vol. 36, no. 5, pp. 978 –987, 2006.

[4] X. Wu, K. Wang, and D. Zhang, “Fuzzy direction element energy feature (FDEEF) based palmprint identification,” in Proc. Int. Conf. Pattern Recognition, vol. 1, 2002, pp. 95–98.

[5] S. Kung, S. Lin, and M. Fang, “A neural network approach to face/palm recognition,” in Proc. IEEE Workshop Neural Networks for Signal Pro- cessing, 1995, pp. 323–332.

[6] H. Imtiaz and S. A. Fattah, “A DCT-based feature extraction algorithm for palm-print recognition,” in Proc. IEEE Int. Conf. Communication Control and Computing Technologies (ICCCCT), 2010, pp. 657–660.

[7] ——, “A spectral domain dominant feature extraction algorithm for palm-print recognition,” International Journal of Image Processing, vol. 5, pp. 130–144, 2011.

[8] M. P. Dale, M. A. Joshi, and N. Gilda, “Texture based palmprint identification using DCT features,” in Proc. Int. Conf. Advances in Pattern Recognition, vol. 7, 2009, pp. 221–224.

[9] J. Lu, Y. Zhao, and J. Hu, “Enhanced gabor-based region covariance matrices for palmprint recognition,” Electron. Lett., vol. 45, pp. 880–881, 2009.