

Wavelet, Gabor Filters and Co-occurrence Matrix for Palmprint Verification

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Abstract— Authentication through the palmprint is a field of biometrics. Palmprint-based personal verification has quickly entered the biometric family. It has become increasingly popular in the recent years due to its ease of acquisition, reliability and high user acceptance. In this paper, we present an authentication system based on the palmprint. We are particularly interested in the feature extraction step. Three feature extraction techniques based on the discrete wavelet transform, the Gabor filters and the co-occurrence matrix are evaluated. The support vector machine is used for the classification step. The results have been validated on the PolyU database related to 400 users. The best results have been achieved with the wavelet decomposition.

Index Terms— Biomtrics, Palmprint verification, PolyU database, support vector machines, wavelet, Gabor filters, co-occurrence matrix

I. INTRODUCTION

The authentication of people by the palmprint is a relatively new biometric technology compared to other modalities such as the signature, face or fingerprint. It has recently attracted the attention of many researchers. Several scientific researches in this area are underway. Fig. 1 shows the evolution of scientific productions on the palmprint biometrics in the IEEE journal. We find that the number of publications has increased by twenty-five times, within ten years, which demonstrates more scientific attention on this authentication technique.

Just like the fingerprint which is a unique signature for each person on the fingertips, the palm print is a unique signature to each individual defined on the palm of the hand. The palmprint can be acquired in a high-

resolution or low-resolution mode (Fig. 2). The high-resolution mode generally implies a resolution greater than or equal to 400 dpi [4, 17, 26]; it is commonly adopted in the case of forensic applications such as the dermatoglyphe and the detection of criminals where the information should be of a high quality [30]. In this mode, the biometric information is extracted from the ridges, singular points and minutiae points. The low-resolution mode generally implies a resolution less or equal to 150 dpi [4, 17] and it is more appropriate to civilian and commercial applications such as the access control to premises, the security of communication, the security of transacting information systems. In the low-resolution mode, the biometric information generally includes main lines which are generally clear and fine lines which are thinner and more irregular than the main lines and ridges scattered all over the palm [12, 18, 23, 24, 31]. Lines and wrinkles are formed between the third and fifth month of pregnancy while peaks appear after birth [26].

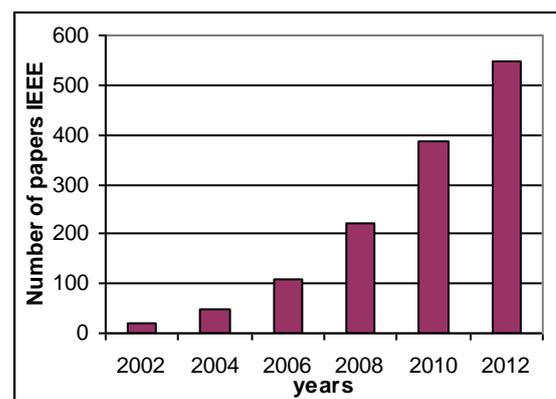


Figure 1. Evolution of the number of IEEE scientific publications on palmprint authentication

We note that the majority of works dealing with the authentication of individuals by the palmprint uses low-resolution images because of its potential applications and low cost [12, 24, 31].

The palmprint is a morphological biometric characteristic which is not genetically deterministic because it is different even for the identical twins [4, 30]. Biometrics by the palmprint has several advantages: the texture of the palmprint is richer than the fingerprint and so it is more discriminate [14, 27], the acquisition systems of the palmprint are less expensive than those of the iris. In addition, the palmprint is listed among the top four biometric characteristics that respond to the requirements of the biometric authentication systems since it appears as one of the less intrusive modalities,

readily accepted by the public, and it does not require any effort or special cooperation of the user [12, 18, 19, 25, 35]. However, the authentication of individuals by the palmprint is not a trivial task. Indeed, the palm of the hand, like any biometric characteristic, is variable in time and sensitive to aging (body weight gain loss or). The acquisition conditions, such as lighting, bad positioning of the hand, dust on the sensor or humidity on the hand are also a constraint to the palm biometric [5]. Despite the significant progress in the recent years, the results are generally lower than those achieved in the case of the biometric authentication by the iris or the fingerprint, hence leaving the field open to other investigations.

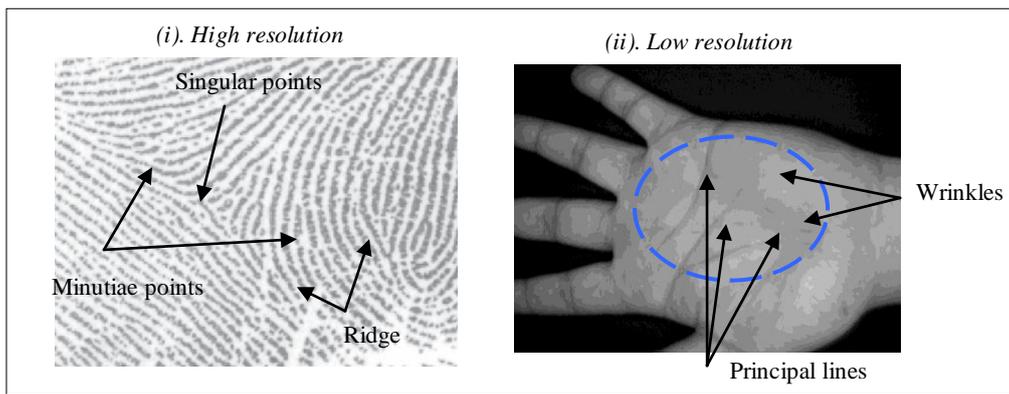


Figure 2. Palmprint acquired mode: (i) high resolution, (ii) low resolution.

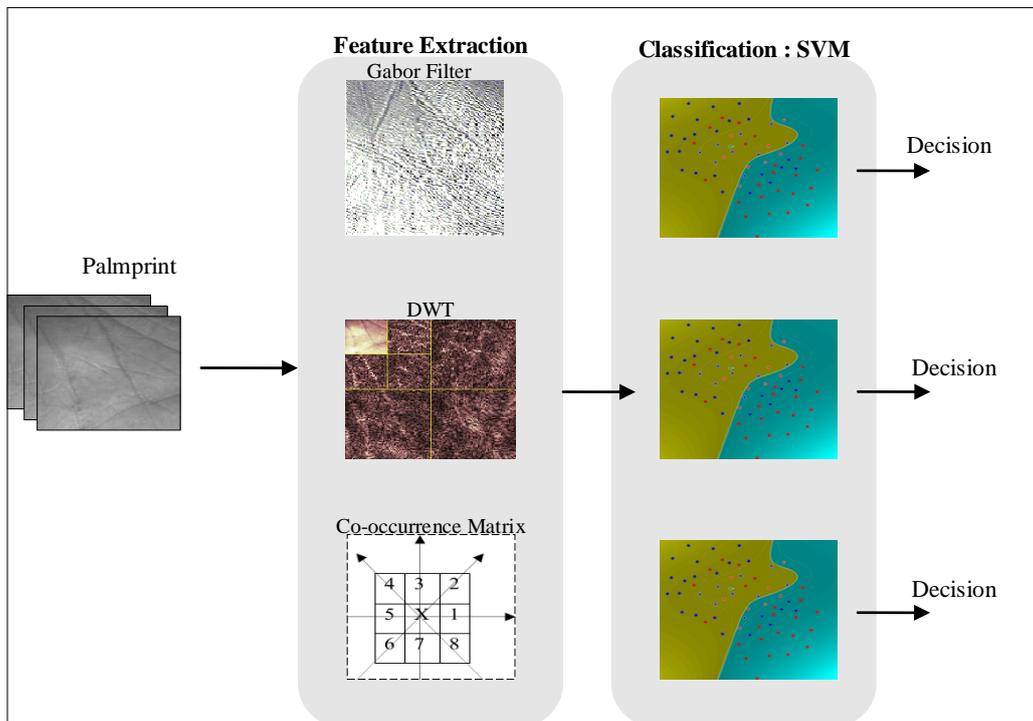


Figure 3. Overall architecture of the proposed system

The literature reveals a variety of analysis approaches of the palmprint. Different feature extraction methods, geometric, structural, statistical, local, global and hybrid, have been exploited. Various classification techniques ranging from a simple Euclidean distance to the hybridization of classifiers have been validated [4, 5]. In this paper, we propose a system of identity verification by the palmprint. This work falls within the framework of our research works in multimodal biometrics [1, 2, 3, 16]. We are particularly interested in the feature extraction step. Three approaches to the feature extraction based on the Discrete Wavelet Transform (DWT), the Gabor filters and the co-occurrence matrix are evaluated (Fig. 3). In the following, we give a report on the biometric authentication by the palmprint. In Section 3, we present the proposed approach. The obtained experiments and results are explained in section 4.

II. RELATED WORKS

Several approaches for checking the identity of persons by the palmprint have been developed in the literature. These approaches can be classified as follows:

- *Line-based approaches*: In this approach, the identity verification is based on the comparison of the lines of the palm of the hand. Different methods have been used for the extraction of lines such as [6, 12, 18, 19, 27, 28]: Sobel masks, Canny filters, Hough transformation, histogram thresholding... The parameters adopted are generally the orientation of lines, their intersection points, their extremities...

- *Subspace-based approaches*: This approach is classically used in the context of face biometrics. In this approach, several linear or nonlinear decompositions are performed for modeling the skin of the hand palm. Among these approaches we mention [12, 15, 17, 20, 32, 34]: Principal Component Analysis (PCA), Independent Component Analysis (ICA), Linear Discriminant Analysis (LDA), Eigenpalms, Fisherpalms...
- *Coding approaches*: This approach exploits the richness of the texture of the palm in the frequency domain through the Fourier transform [19, 24, 33] or the time domain / frequency by the DWT [8, 20, 28, 31], the Discrete Cosine Transform (DCT) [11, 21] and the Gabor filters [13, 15, 17, 25, 55].
- *Statistical approaches*: In this approach, we distinguish local and global statistical methods. The local statistical methods transform images in another area; these images are then divided into several regions (circular, square or elliptical). Statistical measurements such as the mean and standard deviation are calculated for each region and are considered as characteristics [22, 29]. The overall statistical methods operate on the whole image for calculating the features such as [5, 13, 24]: Zernike moments, the variance, the center of gravity and density...

Table 1 presents a selection of works on the authentication of individuals by the palmprint.

Table 1: Summary table showing the characteristics and performance of some palmprint authentication systems. (EER: Equal Error Rate, RR: Recognition Rate)

Ref.	Feature extraction	Classifier	database	Performance (%)
[29]	• Co-occurrence matrix	k-NN	243 users, 1874 images	RR = 98.91
[15]	• PCA • DWT	Euclidean distance	386 users, 7752 images	EER = 11
[25]	• Gabor filters	Hamming distance	150 users, 900 images	EER = 10.3
[18]	• Lines of the palm with the Canny filters	Hausdorff distance	386 users, 7752 images	EER = 2.76
[31]	• DWT	Neural network	7 users 70 images	RR = 97.14
[20]	• Contourlet transforms • Eigenpalms	Euclidean distance	24 users 120 images	RR = 94
[22]	• Local binary patterns	k-NN	146 users 1460 images	RR = 92.72
[21]	• DCT	Canberra distance	50 users 500 images	RR = 97.5
[12]	• Gabor filters • Principal lines • Eigenpalms	• Hamming distance • Similarity measure • k-NN	100 users 600 images	RR = 84.3 RR = 92.5 RR = 95
[8]	• DWT	Euclidean distance	50 users 500 images	EER = 4.07

In what follows, we describe two works on the authentication of individuals by the palmprint. These works have been validated on the PolyU database [7], which we have used to validate our approach.

In [10], the authors present an authentication system by the palmprint. The system is based on analyzing the texture by the DWT. Several wavelet families have been involved; we mention: the DCT Transform Wavelet, the Haar Wavelet, the Slant Wavelet, the Hartley Wavelet... The method consists in calculating the Mean Square Error (MSE) between the reference images and the testing images resulting from the DWT. On the database relating to 8000 images, the recognition rate recorded is close to 93%.

On the same database, Abeysundera et al. [9] present an approach invariant to rotation, and scaling: Scale Invariant Feature Transform. The features retained are the amplitudes and directions of this transformation. The classification is performed by the method of the k-Nearest Neighbor (k-NN). The results achieved present a satisfaction in terms of False Acceptance Rate (FAR = 0.75%), and a low False Rejection Rate (FRR = 12.77%).

III. THE PROPOSED FEATURE EXTRACTION APPROACHES

The feature extraction is a very important step for the design of a biometric system. The objective of this step is to extract variables that describe, unequivocally, the forms belonging to the same class while differentiating them from the other classes. In our work, the proposed approaches are based on the texture analysis. Three techniques are compared: the Gabor filters, the DWT and the co-occurrence matrix.

Gabor filters: The Gabor filters are used to extract the relevant information, both in space and in frequency, relating to the texture. In our work and after various tests, we have retained the values of 30° , 60° , 120° , 150° orientations. For each orientation, different experimentations have led to choosing the three following frequencies: $\pi/2$, π and 2π (Fig. 4). The mean and standard deviation of the filtered images have been selected as texture features. The feature vector is composed of 24 primitives associated with each filtered image.

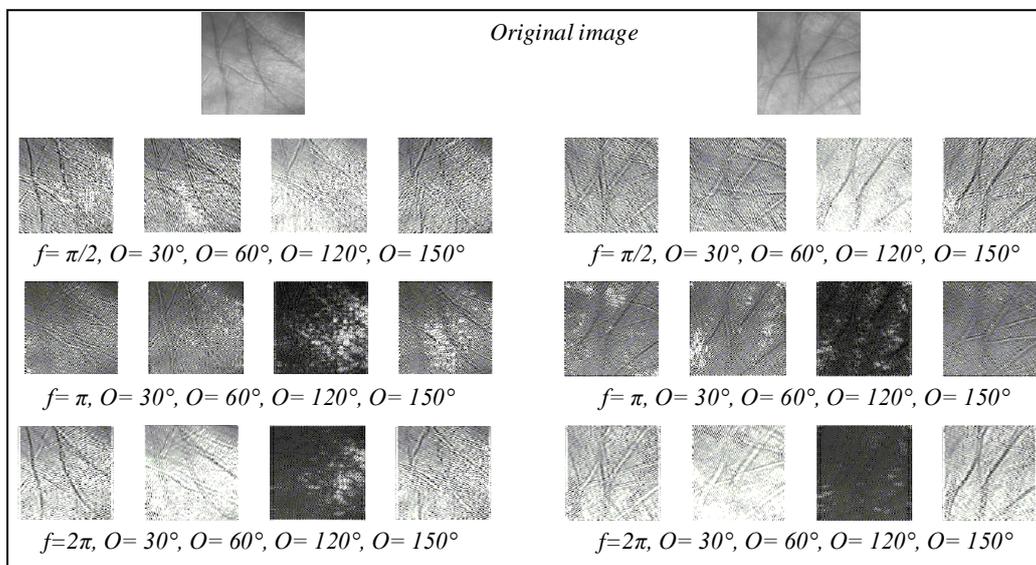


Figure 4. The images resulting from the Gabor filter for the used frequencies and orientations.

Discrete Wavelet Transform: The wavelet transformation has been widely used in various applications in image processing such as denoising, restoration and compression. It has proven its effectiveness especially in the texture analysis. Due to the multi-resolution principle, the DWT provides detailed information both in space and in frequency on the image, which allows analyzing texture at different scales. In our work and after various tests, we have used the Symlet6 at level 2 of the decomposition. The features used are the mean and standard deviation of the approximation matrix and the standard deviation of the horizontal, vertical and diagonal details. The images in Fig 5 show the DWT (Symlet6 at level 2) of two palmprint images.

Co-occurrence matrix: Because of its richness in texture information, the co-occurrence matrix has become one of the most widely used approaches to extract features of textures. The co-occurrence matrix measures the appearance probability of the pairs of the values of the pixels situated at some distance in the image. Several information can be extracted from the co-occurrence matrix. In our work, we have brought our selection on the four most salient parameters in the literature, namely: contrast, correlation, energy and homogeneity.

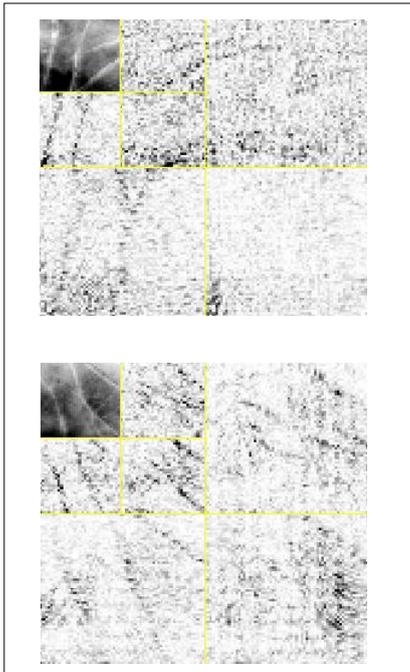


Figure 5. DWT (Symlet6 at level 2) of two palmprints.

IV. EXPERIMENTATION AND RESULTS

The experiments have been performed on an Intel Dual-Core PC, having 1.73GHz, 1GB RAM, with the Matlab R2007 and Visual C++ environment under the Windows XP platform. To confirm the validity of the proposed approach, we have implemented the palmprint databases in PolyU. The palmprint images are obtained from the Hong Kong Polytechnic University 2D_3D palmprint database [7]. The database consists of 400 subjects with 20 palmprint images available for each subject. All palmprints are in greyscale images and a 128×128 resolution which contain the ROI of the palmprint of the right hand. Fig. 6 shows the palmprint image samples of 10 users.

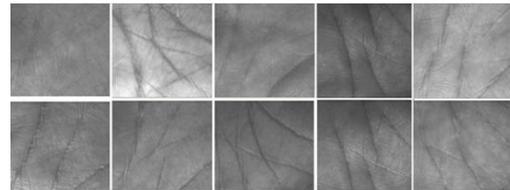


Figure 6. Palmprint image samples

For all feature extraction approaches, we have used the same type of classifier, namely the Support Vector Machines (SVM) with a radial base function. The class-modular classification architecture has been adopted. Table 2 summarizes the performance of the three implemented approaches.

Table 2: Performances recorded for the various proposed approaches

	Approach	Feature set size	Database	Recognition Rate (%)	Time for features extraction (s)
Method in [10]	DWT & MSE	--	PolyU 2D, 400 people, 8000 images	93	--
Method in [9]	SIFT & KNN	--		93.24	--
Proposed I	Gabor & SVM	24		90.57	1.62
Proposed II	DWT & SVM	5		95.20	0.85
Proposed III	CM & SVM	4		91.19	1.12

The analysis of these results shows the superiority of the DWT in terms of recognition rate compared to other methods. Indeed, the principle of multi-resolution DWT has provided accurate information both in space and frequency on palmprint, which allowed an analysis of the texture at different scales. Based on the results in [10], we also see the effectiveness of our choice of parameters from the wavelet transform, which are the mean and standard deviation of the Approximation

Matrix (AM), the Standard Deviation (SD) of the Horizontal (HD), and the Vertical (VD) and Diagonal Details (DD). Fig 7 shows the distribution of the five parameters resulting from the DWT for a random selection of four users from the PolyU database. We observe the relevance of our features since the overlap areas are much reduced for the mean and standard deviation of the matrix approximation.

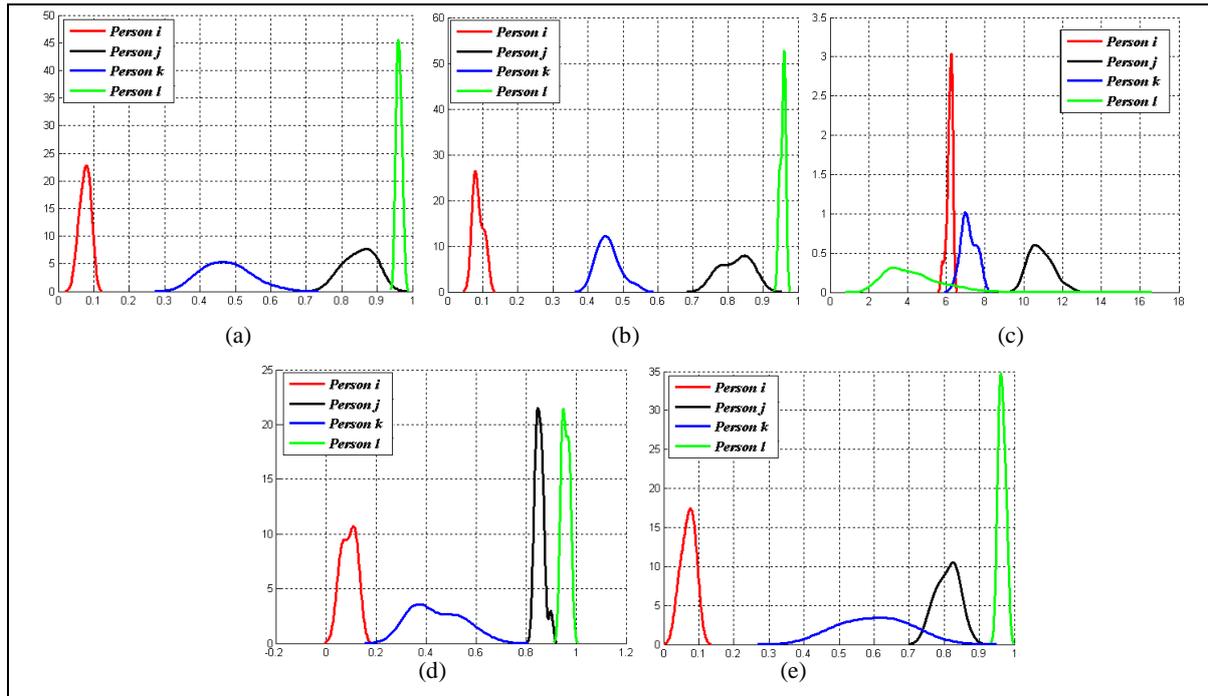


Figure 7. Distribution of features from the DWT. ((a): mean of the AM. (b): SD of the AM. (c): SD of the HD. (d): SD of the VD. (e): SD of the DD)

In terms of process speed, we have measured, for each approach, the computation time required for the extraction of the characteristics related to one person. From Table 3, we find that the characterization by the wavelet produces a good compromise between the overall system performance and the speed of execution.

The texture analysis by the Gabor filters has led to 24 primitives with a relatively heavy computation time and average performances. This performance can be improved by performing a step of optimization by the genetic algorithms or the PCA to eliminate the redundant frequencies and orientations.

V. CONCLUSIONS

In this paper, we have addressed the problems related to the feature extraction from the palmprint in a framework related to the biometric authentication of individuals. Three textural analysis techniques based on the Gabor filters, the Discrete Wavelet Transform and the co-occurrence matrix have been implemented with the same classifier, namely the support vector machines. The results recorded on a database of 8000 images have shown the effectiveness and relevance of the parameters resulting from the wavelet decomposition.

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