Palmprint Characterization Using Multi-wavelet Transform for Human Identification

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Abstract

The human hand presents the source for a numerous of physiological biometric features, from these are palmprint, hand geometry, finger geometry and the vein pattern on the dorsum of the hand, are mostly used in many fields for different applications. Lines and points are extracted from palms for individual identification in original image or frequency space. In this paper, a preprocessing to extract the central part from the input palmprint image, next a 2-D multi-wavelet transform is used to convert the palmprint image into 16 sub-bands, and the texture feature vectors, energy and entropy for each of the 16 sub-bands is computed and normalized with min-max method for individual identification. The correlation distance is used as a similarity measure. The experimental results point up the effectiveness of a method in either using low resolution or noisy images.

Keywords: Human, Biometrics, Palmprint, Multi-wavelet, Texture Feature, Correlation

خصائص راحة اليد بأستخدام التحويل المويجي المتعدد لتعريف الاشخاص

الخلاصه

يد الإنسان تمثل مورد للعديد من السمات الخاصة بالمحددات الفيزياوية، منها راحة اليد، هندسة اليـد، هندسة الأصابع ، أنماط الأوردة على ظهر اليد، والتي تم استخدامها في العديد مـن التطبيقـات. الخطـوط والنقاط يتم استخلاصها من راحة اليد بصورة مباشرة من الصورة أو بعد تحويلها إلى الفضاء الترددي. فـي هذا البحث تتم عملية المعالجة الأولية على الصورة المدخلة لراحة اليد لاستخلاص منطقـة مربعـة منهـا. يتبعها تطبيق التحويل المويجي المتعدد في الفضاء الثنائي الأبعاد، لتتحول معه الصورة إلى 16 حزمة، ومن ثم يتم استخلاص متجهات السمات البنيوية، الطاقة والانتروبي, وجعـل قيمهـا سـوية باسـتخدام طريقـة الأصغر -الأكبر، لكل من الحزم الستة عشر الناتجة، لغرض تمييز الأشخاص. أي صـورتان لراحـة اليـد تعتبران مختلفتان بالاعتماد على مسافة الارتباط. نتائج الاختبارات عبرت عن مدى فعالية الطريقة الجديـدة المطبقة في حالة وجود الضوضاء مع استخدام للدقة منخفضة

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1. Introduction

Computer-based personal identification, also known as biometric computing, which attempts to recognize a person by his/her body or behavioral characteristics [1]. The human hand contains a wide variety of measurable characteristics that can be used by biometric identification systems. These characteristics are typically extracted from the visible and infrared images of the hand. Compared with the other physical characteristics, palmprint based identifier has several advantages [2]: low-resolution imaging, low intrusiveness, stable line features and high user acceptance. A typical palmprint image captured by a CCD camera, using a very low resolution (65 dpi) is depicted in Figure (1). The black rectangle at the middle left of the image is the palmprint fixture. The palm is the inner surface of the hand between the wrist and the fingers. As illustrated in the figure, the main patterns in a palmprint can be generalized as principal lines, wrinkles and creases. There are usually three principal lines in a palmprint: the heart line, the head line, and the life line. These lines vary little over time, and their shapes and locations on the palm are the most important physiological features for individual identification. Wrinkles are much thinner than the principal lines and much more irregular. Creases are the relatively detailed features that exist all over the palmprint, just like the ridges do in a fingerprint [3].

Palmprint based identifier can be divided into an off-line palmprint, where all palmprint samples are inked on paper, then transmitted into a computer through a digital scanner and online palmprint, the samples are directly obtained by a palmprint scanner. The classification of palmprint-based biometric (on-line or off-line) systems is according to the applied feature-generation method into systems that extract features in the original image space or in the transformed image space [4]. With the works that appear in the literature based on transformed image space are eigenpalms [5], Gabor filters [2], Fourier Transform [6], Wavelets [7], and. Radon transform is proposed [8], which can extract principal lines effectively and efficiently even in the case that the palmprint images contain many long and strong wrinkles.

The palmprint identification system consist of six modules, palmprint acquisition, preprocessing, feature extraction, post processing, matching and storage, and two mode, enrollment and identification. Figure (2) depict a block diagram to describe the relationship between the six modules, and the two modes for identification process [2].

In this paper, a spectrum based textural feature vectored is extracted from palmprint image for individual identification. A preprocessing is achieve to extract the central part from the input palmprint image, followed by apply a 2-D multi-wavelet transformation. The result 16-sub-bands are used for textural feature vector extraction, energy and entropy. The result feature vectors is normalized using min-max to the range [0, 1], and combined to perform one feature vector of size 28. The remaining sections are organized as follows: preprocessing steps are mentioned in Section 2. Palmprint feature extraction is explained in Section 3. Experimental results are given in Section 4. Finally, Section 5 conclusions and summaries to the main results of this paper.

2. Preprocessing

A sub-image from the captured image is obtained in a five major steps by defending a coordinate system, using the gaps between the fingers as reference points. The sub-image represents the central part of a palmprint, which it is important for a reliable feature measurement, and to eliminate the variations caused by rotation and translation. The five major steps are [2]:

1. The hand image of 256 gray levels as shown in Figure (3-a) are applied with a low-pass filter. Then a threshold is used, to convert these images into a binary image using the threshold method, Figure (3-b) is the result binary image.
2. The binary images are traced to obtain the contours of the hand shape by a boundary-tracking algorithm. The start points, and end points, of the holes are then market, Figure (3-c) is the result hand contours.
3. The minimum mean radial distance from all the points on the hand contour to the hand centroid are selected as the anchor points.
4. The origin of the coordinate system is defined as the point between index and middle finger and the point between the middle and pinky finger. The slope of the line passing through the anchor points is determined and each band image is rotated in the direction of the slope around the anchor midpoint, see Figure (3-d).
5. Extract a sub-image with the fixed size on the basis of coordinate system, which is located at the certain part of the palmprint, see Figure (3-e).

3. Feature Extraction

This section defines the used textural feature extraction method, which includes transforming and matching. The motivation for using a 2-D multi-wavelet transform in the palmprint identification is first discussed.

3.1 Multi-Wavelet Transform

A multi-wavelet is another form of a multi-scale representation which uses several scaling functions and mother wavelets [9]. One of the most well-known multi-wavelets transform is called GHM, which is constructed by Geronimo, Hardin, and Massopust. GHM scaling functions and multi-wavelets are depicted in Figure (4). The GHM scaling functions have short support and are symmetric about their centers. Also two other important features are the orthogonality of integer translates of scaling functions and an approximation order of two. The low- and high-pass equivalent filters of the GHM multifilters are depicted in Figure (5) for clarification. A 2-D multi-wavelet decomposes each sub-image into 16 sub-images. Figure (6) depicts the 16 sub-images of a typical decomposed to the first level using the GHM multi-wavelet based critically sampled method for Daubechies-6 [10]

3.2 Transforming Feature Extraction

Normally, principal lines and wrinkles are simply spotted from the captured palmprint images, see Figure (3-a), however, these lines do not effective the high accuracy due to their similarity among different palms as depicted in Figure (7). Thus, wrinkles tack the essential role in palmprint recognition accurately. These inspire the application of texture analysis to palmprint images. The method for feature extraction is based on decomposing the sub-images and calculating the entropy and energy of each of the sub-bands. In an N × N sub-image, normalized energy and entropy are computed according to the following relations [9]:

$$Energy = \frac{\sum_i \sum_j c_{ij}^{2}}{N^2} \quad \text{........ (1)}$$

$$Entropy = \frac{\sum_i \sum_j \left[\frac{c_{ij}^2}{norm^2}\right] \log_2 \left[\frac{c_{ij}^2}{norm^2}\right]}{\log_2^{N^2}} \quad \text{.... (2)}$$

Where x_{ij} is the ijth pixel value of the sub-images, and

$$norm^2 = \sum_i \sum_j c_{ij}^2 \quad \text{...... (3)}$$

A 16 sub- images is generated using a 2-D multi-wavelet As a result, 28 features for each sub-image is extracted

3.3 Normalization

A feature is normalized by scaling its values so that they fall within a small-specified range, such as 0.0 to 1.0. For distanced-based methods, normalization helps prevent features with initially large ranges from outweighing features with initially smaller ranges. Min-max normalization performs a linear transformation on the original data. Suppose that mina and maxa are the minimum and the maximum values for feature A. Min-max normalization maps a value v of A to v' in the range [new-mina, new-maxa] by computing:

$$v' = \left(\frac{(v-mina)}{(maxa-mina)}\right) * (new-maxa - new-mina) + new-mina \quad \text{.....(4)}$$

The min-max normalization operation transforms each feature vector (energy, and entropy) to the rang [0, 1]. The result feature vectors are linked together to perform one feature vector of size 28, which represents the characteristics of the individual.

3.4 Matching Method

Let X and Y are two palmprint feature vectors where, $x_i \in X$, $y_i \in Y$, i=1… n. to calculate the degree of association, a correlation distance is defined as [11]:

$$R = 1 - r \quad \text{...... (5)}$$

Where r is the linear correlation coefficient which is given by the formula [11]:

$$r = \frac{\sum_{i=1} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1} (x_i - \bar{x})^2} \sqrt{\sum_{i=1} (y_i - \bar{y})^2}} \quad \text{....... (6)}$$

Where $\bar{x}$ is the mean of the vector X, $\bar{y}$ is the mean of the vector Y.

The correlation distance determines the genuine or forged of a query sample, if the value R is greater than zero, then the owner of query sample is claimed to be individual X. Otherwise, the query sample is classified as a forged pattern.

4. Experimental Results

4.1 Palmprint Database

A palmprint database contains 100 palmprint images collected from 10 individuals, as a sample of 10 images depicted in Figure (8(a-j)), 4 of them are female, 6 of them are male. Each of them is asked to provide about 10 images for their left palm. Originally, the collected images have size, 584×484 pixels with 75dpi resolution. The gathered palmprints images belong to individuals place their hands freely on the platform of the scanner when scanned. This results in palmprint images with different shifts and rotation. Therefore, some preprocessing operations are required to correct the orientation of the image. Next, a sub-image which represents the central part of the palm is extracted so that the feature extraction process can be performed on a fixed size of image. The size of the central part for each palmprint image is 256× 256 pixels and then resized to 128×128 pixels. The result is 200 sub-images named (grop1), and (grop2) 100 samples in each.

A 2-D Multi-wavelet transform is applied for each sub-image in grop1 and grop2, followed by extracting the textural features (energy, and entropy) for each of the result 16-subbands. A min-max normalization take place to convert the result feature vector to elements between [0, 1] the results normalized feature vector is labeled manually, and 10 samples (one for each individual) where used to form a database, which named the Enrollment Database (EDB1 (EDB2)), the other 90 samples where used to perform the identification. Tables (1) depict the correlation distance for each palm in EDB1, based on using the extracted feature vector (energy, and entropy).

4.2 Identification Tests

A comparison based on using the correlation distance for each of the rest 90 query samples of (grop1 (grop2)) with the other 10 reference in (EDB1 (EDB2)). Tables (2) depict the number of success identification for each of the 90 query samples for EDB1, and Table (3) depicts the number of success identification for each of the 90 query samples for EDB2.

A Gaussians white noise is added for each of 180 sub-image samples in different values of signal-to-noise ratio per sample, and tested for individual identification using the method. Table (4) depicts the number of success identification.

5. Conclusion and Summary

The palmer which, presents physiological biometric features for an individuals identity, are mostly used in many fields for different applications. Lines and points are extracted from palmers for personal identification in original image or frequency space. This paper presents a spectrum-based textural feature extraction method using low resolution and noisy palmprint images for personal identification. A sub-image which represents the central part of a palmprint image is extracted. This process is important for reliable feature measurements, and to eliminate the variations caused by rotation and translation. A palmprint images is considered as a texture image, so a 2-D multi-wavelet transform based critically sampled method for Daubechies-6 filter is employed on sub-images, to capture the texture feature vector (energy, and entropy) for each of the result 16-sub bands. A min-max normalization method is used to re-arrange the feature vector to [0, 1]. The result feature vector of size 28. The proposed system is implemented for identification 10 individuals, with success of identification rate of 98%. The method investigates the application of 2-D multi-wavelet transform to biometrics palmprint in different noise levels and low-resolution images, and the method gives a success identification of 98%, and 98%.

The used transform has appealing properties such as short support and are symmetric about their centers. Also two other important features are the orthogonality of integer translates of scaling functions and an approximation order of two, which gives the result feature vector more effectiveness in the identification process. The used normalization gives the effectiveness of the methods.

6. References

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Table (1) Depict the correlation distance for EDB1

	Palm1	Palm2	Palm3	Palm4	Palm5	Palm6	Palm7	Palm8	Palm9	Palm10
Palm1	0	1.6011e-006	1.9425e-006	1.1041e-006	1.5716e-006	2.1797e-006	1.0625e-006	1.6822e-006	1.3479e-006	1.1242e-006
Palm2	1.6011e-006	0	3.2323e-007	4.2675e-007	4.2036e-007	3.1067e-007	2.2539e-007	1.79e-007	5.4791e-007	6.7308e-007
Palm3	1.9425e-006	3.2323e-007	0	5.6728e-007	4.4645e-007	3.6657e-007	9.19e-007	3.0025e-007	1.8019e-007	1.2118e-006
Palm4	1.1041e-006	4.2675e-007	5.6728e-007	0	1.0128e-006	9.0391e-007	4.1379e-007	4.2915e-007	2.9054e-007	1.1927e-006
Palm5	1.5716e-006	4.2036e-007	4.4645e-007	1.0128e-006	0	5.2351e-007	8.1803e-007	2.6042e-007	6.806e-007	3.5249e-007
Palm6	2.1797e-006	3.1067e-007	3.6657e-007	9.0391e-007	5.2351e-007	0	7.8658e-007	4.5056e-007	7.3142e-007	1.0515e-006
Palm7	1.0625e-006	2.2539e-007	9.19e-007	4.1379e-007	8.1803e-007	7.8658e-007	0	4.9207e-007	9.2705e-007	5.5148e-007
Palm8	1.6822e-006	1.79e-007	3.0025e-007	4.2915e-007	2.6042e-007	4.5056e-007	4.9207e-007	0	4.3613e-007	6.0151e-007
Palm9	1.3479e-006	5.4791e-007	1.8019e-007	2.9054e-007	6.806e-007	7.3142e-007	9.2705e-007	4.3613e-007	0	1.3e-006
Palm10	1.1242e-006	6.7308e-007	1.2118e-006	1.1927e-006	3.5249e-007	1.0515e-006	5.5148e-007	6.0151e-007	1.3e-006	0

Table (2) Depict the success identification for EDB1

	Palm1	Palm2	Palm3	Palm4	Palm5	Palm6	Palm7	Palm8	Palm9	Palm10
Palm1	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm2	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm3	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm4	**0**	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**
Palm5	**0**	**0**	**0**	**1**	**8**	**0**	**0**	**0**	**0**	**0**
Palm6	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**	**0**	**0**
Palm7	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**	**0**
Palm8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**
Palm9	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**8**	**0**
Palm10	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**

Table (3) Depict the success identification for EDB2

	Palm1	Palm2	Palm3	Palm4	Palm5	Palm6	Palm7	Palm8	Palm9	Palm10
Palm1	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm2	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm3	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm4	**0**	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**
Palm5	**0**	**0**	**0**	**1**	**8**	**0**	**0**	**0**	**0**	**0**
Palm6	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**	**0**	**0**
Palm7	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**	**0**
Palm8	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**
Palm9	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**8**	**0**
Palm10	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**

Table (4) Depict the number of success identification

	Palm1	Palm2	Palm3	Palm4	Palm5	Palm6	Palm7	Palm8	Palm9	Palm10
No. of Success Identification	18/18	18/18	18/18	18/18	16/18	18/18	18/18	18/18	16/18	18/18

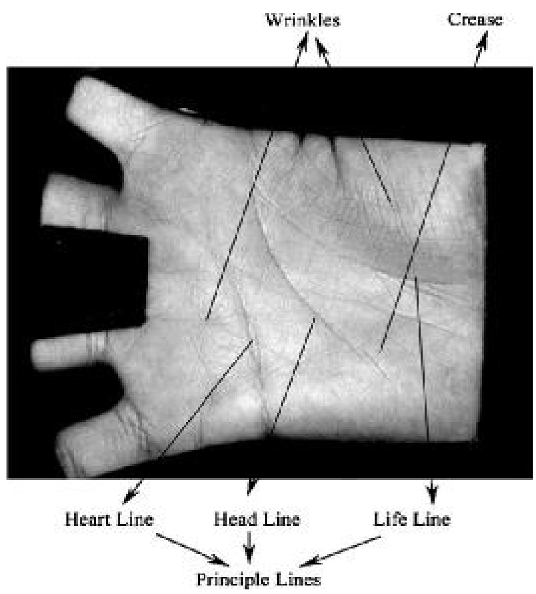

Figure (1) The main patterns in a palmprint.

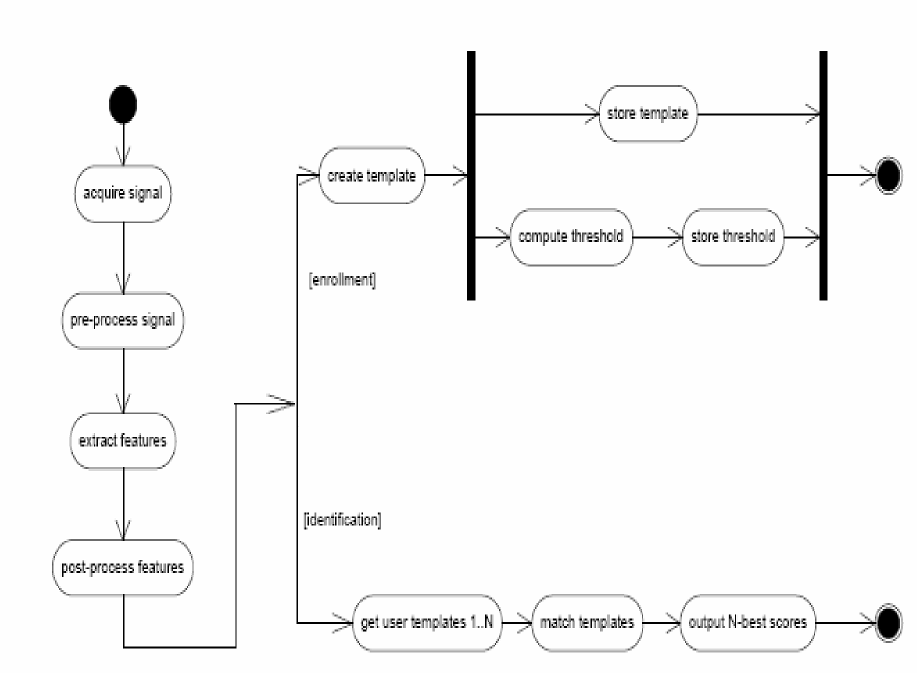

Figure (2) The palmprint Identification System.

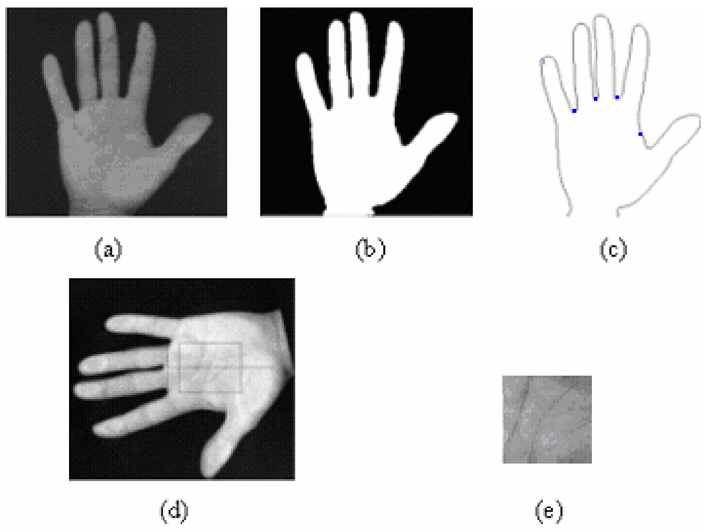

Figure (3(a-e)) the preprocessing steps

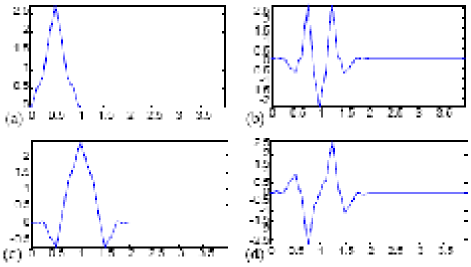

Figure (4) GHM scaling functions

(a) f_1 (b) f_2 GHM mother wavelets (c) y_1 (d) y_2

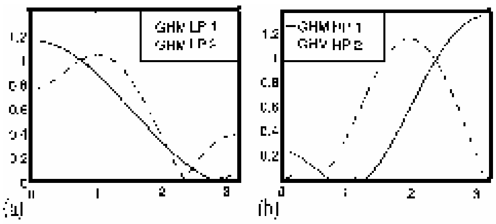

Figure (5) Equivalent scalar flitters for GHM multi-wavelet.

(a)Low-pass filters and (b) high-pass filters.

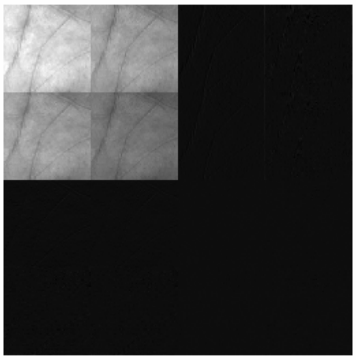

Figure (6) First level 2-D multi-wavelet decomposition

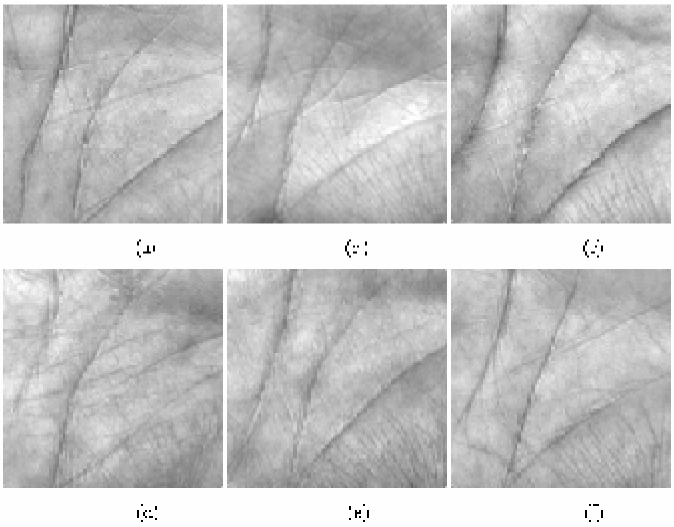

Figure (7(a-f)) The similarity amongst different palms

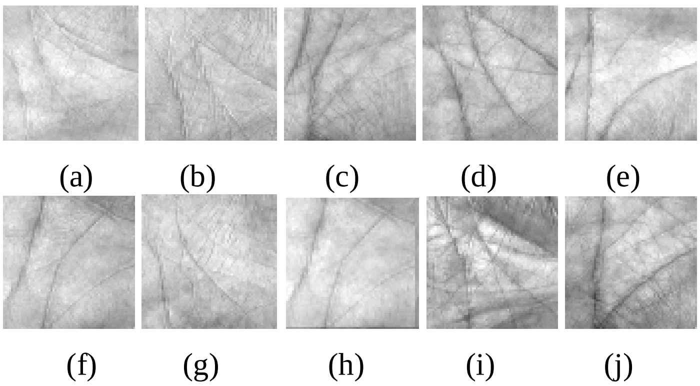

Figure (8(a-j)) Shows typical images from the databases.