Chapter 85
Palmprint Identification Using Invariant Moments Algorithm Based on Wavelet Transform

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Abstract Because of the uniqueness of palmprints found on the palms of humans, palmprint identification has been used in several applications. It is usually associated with criminal identification, and has now become more popular in civilian applications. Therefore, the aim of the proposed model is to improve personal identification based on extracting shape feature using moments algorithm based on wavelet transform and matching algorithm, which is proposed in this model. This model has shown promising results without affecting rotation, translation and scaling of objects, because it is associated with the use of a good description of shape features. This system has been tested using databases from the Chinese Academy of Sciences (CASIA), in Beijing. By using false rejection rate (FRR) and false acceptance rate (FAR), we calculated the accuracy of identification. The experiment shows 98 % identification rate in the CASIA database.

85.1 Introduction

A wide variety of systems require reliable personal authentication schemes to either confirm or determine the identity of individuals requesting their services. The purpose of such schemes is to ensure that the rendered services are accessed by a legitimate user, and not anyone else. Traditionally, passwords (knowledge-based security) and identification cards (token-based security) have been used to restrict access to systems. However, security can be easily breached in these systems when a password is divulged to an unauthorized user or a card is stolen by

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an impostor. Furthermore, simple passwords are easy to guess (by an impostor) and difficult passwords may be hard to recall (by a legitimate user). The emergence of biometrics has addressed the problems that plague traditional verification [1]. Among all biometric traits, palmprint has one of the highest levels of reliability and has been extensively used by forensic experts in criminal investigations. A palmprint is obtained from the central surface of the hand, between the wrist and the fingers. Figure 85.1 shows the shape and details of a palmprint.

A simple biometric system has four important modules [2], which are the following:

- The Sensor Module, which captures the biometric data of an individual. An example is a palmprint sensor that captures palmprint impressions of a user.
- The Feature Extraction Module, in which the acquired data is processed to extract feature values. For example, extract shape feature by using moments algorithm.
- The Matching Module, in which the feature values are compared against those in the template by generating a matching score. For example, in this module, the number of matching minutiae between the query and the template can be computed and treated as a matching score.
- The Decision-making Module, in which the user's claimed identity is either accepted or rejected based on the matching score generated in the matching module.

The rest of paper organized as follows: Sect. 85.2 explains in details the methodology that used in this paper. Section 85.3 introduces the results and discussion. Finally, Sect. 85.4 concludes the paper.

85.2 Methodology

This study explains and discusses the proposed method in performing palmprint recognition. The first stage is the acquisition of hand images from the CASIA. The second stage is pre-processing, which affects two main steps: including the binarizing hand image and extracting the palmprint region from the whole hand. This stage helps strip images from noise. The final stage includes feature extraction methods and matching techniques, such as invariant moments, used in computer vision applications. In this stage, the shape descriptor approach is employed in extracting global features of the palmprint, based on the wavelet transform, by decomposing each palmprint image into four bands and deriving seven invariant moments for each band. Finally, matching is carried out to perform identification. This method can generate more accurate results in less time. Points of interest in the identification of the palmprint are the features of an image, the change in the scale and rotation of the image's features.

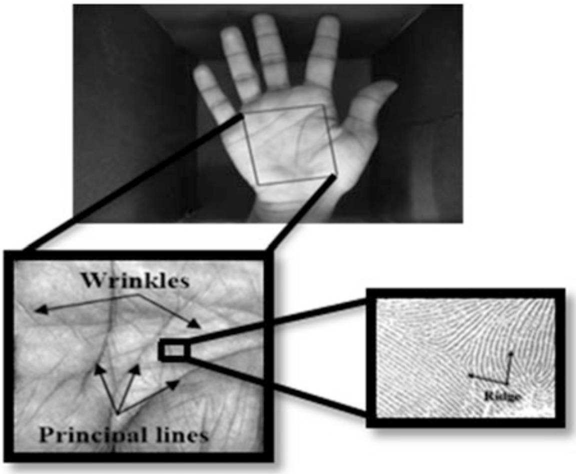


Fig. 85.1 Shape and details of a palmprint

85.2.1 Hand Image Acquisition (Data Set)

The databases were obtained from the CASIA. Images of the hand were obtained using a flatbed scanner set at 256 grayscale. Grayscale images are mere representations of the image using only one color, which is gray, to cover the entire image. In a grayscale image, the density of the color component is used to represent the image. This component carries more information about the image. It also reduces the size of the image dimensions, for example, instead of three bytes, the image will be reduced gradually to a single byte (which is 0–255 in the decimal system). The image, when converted to this type of color range, it becomes easier to explain and promote. This property is also another feature of the grayscale mode [3]. In this study, we used the CASIA database. The CASIA database contains 800 images of the hands of 50 subjects. All images measure 640 $\times$ 480 pixels. Each user submitted eight pictures of their right hand and eight pictures of their left hand. The images show 256 gray levels on the flatbed scanner. The scanner is link-free, and therefore users are free to put their hands anywhere on the scanner as long as their hands are placed face down. Figure 85.2 shows samples of the left hand images. To ensure that the reproduction of your illustrations is of a reasonable quality, we advise against the use of shading. The contrast should be as pronounced as possible.

85.2.2 Image Pre-processing

Image processing is an area described by the need for intensified efforts to create an experimental feasibility of the proposed solutions to a specific problem. Image processing is a discipline in computer science. Each image has a value of more

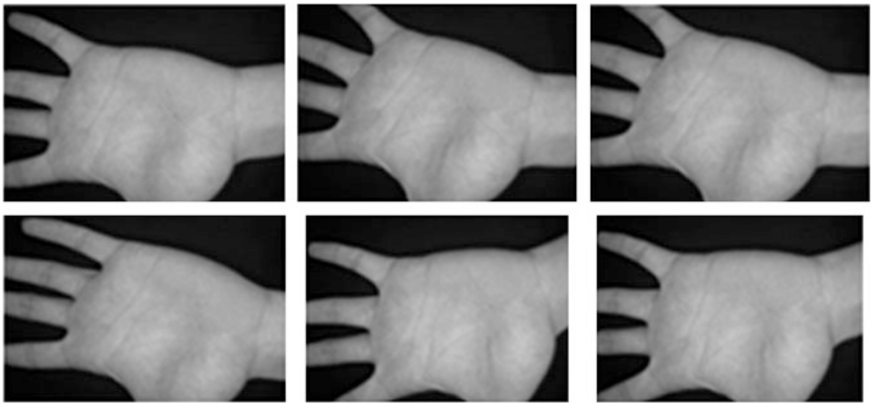


Fig. 85.2 Samples of the left hand images

than tens of thousands of words and provides a number of meanings. The digital images can be defined through the various definitions. For example, a digital image can be formulated as a function of two dimensions, and (X, Y), where x and y are spatial coordinates [4]. Values F (X, Y) represent the clarity or jamming of the image at a certain point. All the digital images of different elements, each element have a location and a value. These elements are referred to as image elements and pixels. The image processing is the study of the use of a variety of algorithms that were conducted on the pictures, where all of the input and output of the algorithms is the picture. First, we binarized hand image from the original image, at this stage a global threshold used to extract the image from rare hand. Figure 85.3 shows the original image and binarized image.

After that, extraction of the region from the whole hand will be done [5]. Figure 85.4 shows a sample of the extracted images.

85.2.3 2D Wavelet Transform

After extracting the region from the whole hand, 2D filter banks will apply to these regions, to get decomposed images into four bands [6], low–low pass filter, low–high pass filter, high–low pass filter and high-high pass filter (LL, LH, HL, HH) (Fig. 85.5).

85.2.4 Invariant Moments Algorithm

Recognition of objects efficiently can extract feature points of objects (palmprint) to create a powerful feature descriptor or the representation of objects. Hu [7] has introduced a technique to extract the shape features form of images, which are

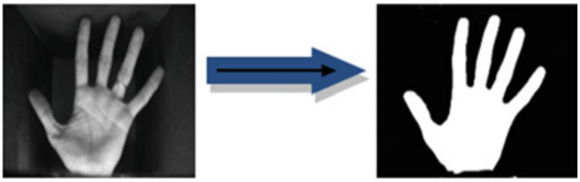
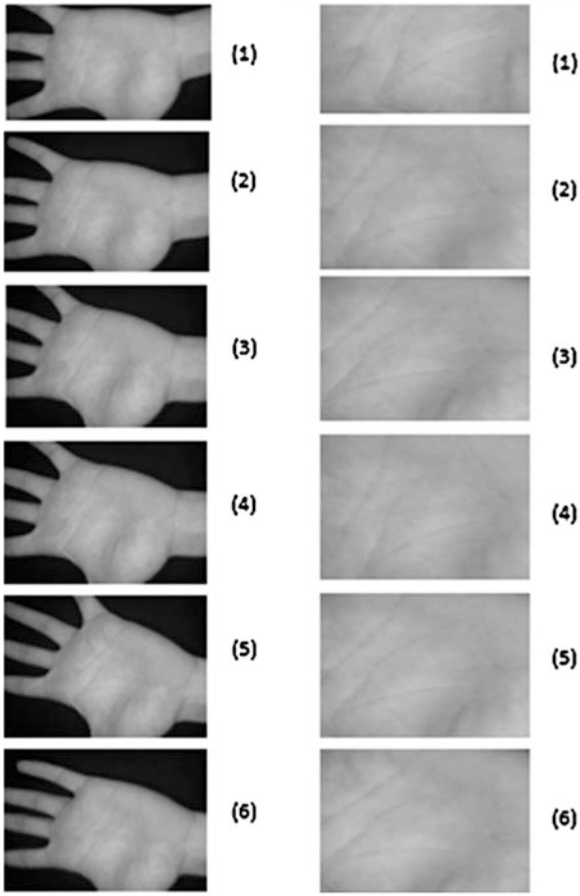


Fig. 85.3 Binarized hand images of the left and hands

Fig. 85.4 Samples of extracted left palmprint of one user from the CASIA database



called invariant moments. These features are invariance to translation, rotation, and change in scaling.

The advantage of the moments over other techniques is the implementation of the previous descriptors is straight forward, and they also carry a "physical" interpretation of boundary shape. Hu was first to set out the mathematical foundation for two-dimensional moment invariant and demonstrated their applications

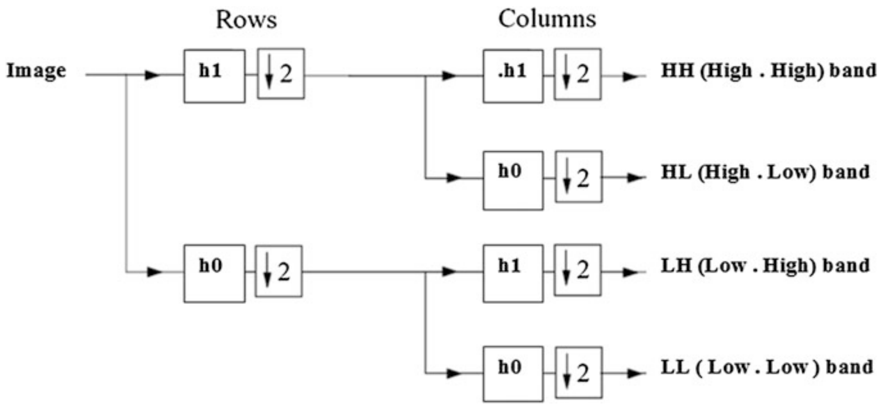


Fig. 85.5 2D filter bank analysis

to shape recognition. Invariant moments were first applied to aircraft shapes and have been proven to be fast and reliable. These values are invariant with respect to translation, rotation and shape scaling.

Hu defines seven of these shape descriptor values computed from central moments through order three that are independent to object translation, scale and rotation.

$$\Phi 1 = \eta 20 + \eta 02 \tag{85.1}$$

$$\Phi 2 = (\eta 20 - \eta 02)2 + 4\eta 211 \tag{85.2}$$

$$\Phi 3 = (\eta 30 - 3\eta 12)2 + (3\eta 21 - \eta 03)2 \tag{85.3}$$

$$\Phi 4 = (\eta 30 + \eta 12)2 + (\eta 21 + \eta 03)2 \tag{85.4}$$

$$\begin{aligned}\Phi 5 = {} & (\eta 30 - 3\eta 12)(\eta 30 + \eta 12)[(\eta 30 + \eta 12)2 \\ & - 3(\eta 21 + \eta 03)2] + (3\eta 21 - \eta 03)(\eta 21 + \eta 03) \\ & [3(\eta 30 + \eta 12)2 - (\eta 21 + \eta 03)2]\end{aligned} \tag{85.5}$$

$$\begin{aligned}\Phi 6 = {} & (\eta 20 - \eta 02)[(\eta 30 + \eta 12)2 - (\eta 21 + \eta 03)2] \\ & + 4\eta 11(\eta 30 + \eta 12)(\eta 21 + \eta 03)\end{aligned} \tag{85.6}$$

$$\begin{aligned}\Phi 7 = {} & (3\eta 21 - \eta 03)(\eta 30 + \eta 12)[(\eta 30 + \eta 12)2 \\ & - 3(\eta 21 + \eta 03)2] + (3\eta 12 - \eta 30)(\eta 21 + \eta 03) \\ & [3(\eta 30 + \eta 12)2 - (\eta 21 + \eta 03)2]\end{aligned} \tag{85.7}$$

85.2.5 Identification

To obtain the identification accuracy of our palmprint system, each of the palmprint images was matched with all of the palmprint images in the database. A matching is noted as a correct matching if two palmprint images are from the same palm. If we suppose the query image is an X, and images in the database are N, we must compare X with N.

85.3 Results and Discussion

The main objective of this study is to obtain higher authentication accuracy by using a proposed algorithm after performing all previous stages. In this stage, 50 users from the CASIA database had features of their palmprints extracted using the invariant moment algorithm. This stage is considered fundamental in building the proposed system of recognition. To find out how accurate this algorithm is, we need to determine the accuracy rate of the identification phase. For determining accuracy rate, we have used two factors, which were FRR and FAR.

85.3.1 Results Based on Wavelet Transform

After applying wavelet transform (2D filter bank). The output is images that had been decomposed into four bands (LL, LH, HL, HH). Figure 85.6 shows an example of decomposed palmprint images.

85.3.2 Results Based on Moments Algorithm

After applying wavelet transform on palmprint images and decomposing these images into four bands (the output from the previous stage), The invariant moments algorithm was applied for deriving seven moments from each band. Table 85.1 shows values of the seven moments of four bands for one palmprint user (Table 85.2).

85.3.3 Accuracy Rate of Identification Phase

For the purpose of calculating the accuracy rate of the proposed method to perform the identification phase by matching query palmprint image with each one stored in the database based on FRR and FAR. To calculate the FRR factor, samples of

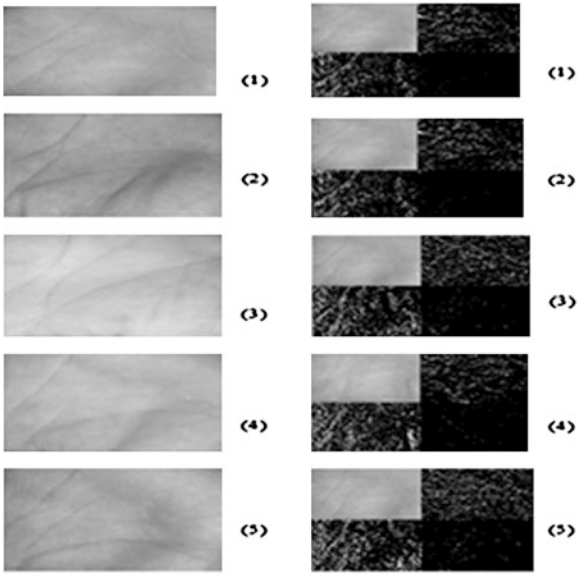


Fig. 85.6 Samples of decomposed palmprint for five users

Table 85.1 Values of the seven moments of four bands for one palmprint user

Moments	LL	LH	HL	HH
First moment	9.66809E-04	0.72658299392	0.49137043951	34.0659780176
Second moment	6.78459E-12	3.3876777E-03	4.8144644E-04	457.609538309
Third moment	2.08395E-13	8.92198E-03	6.57074E-03	14562.2738551
Fourth moment	1.14094E-13	9.5015245E-03	3.8902797E-03	1665.46619179
Fifth moment	–3.1786E-20	7.7039764E-04	2.3161658E-04	–4608230.8966
Sixth moment	2.19293E-19	5.1328263E-04	–4.361702E-05	27447.6711358
Seventh moment	–1.1909E-26	–6.772396E-05	–1.531511E-05	6526394.74011

Table 85.2 Final seven moments which were derived from Table 85.1 for one palmprint

Moment	Value
First moment	8.82122456503965
Second moment	114.403351858058
Third moment	3640.57233696204
Forth moment	416.369895895987
Fifth moment	–1152057.72390458
Sixth moment	6861.91790138718
Seventh moment	1631598.68500723

Table 85.3 Accuracy type

No. set	FRR (%)	FAR (%)	Accuracy (%)
1	6.66	6.66	93.33
2	6.66	0	96.66
3	0	0	100
4	0	0	100
5	0	0	100
Rate	1.33	2.66	98

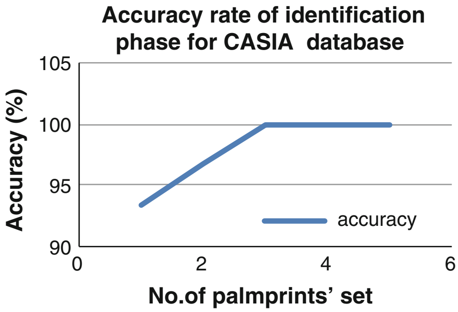


Fig. 85.7 Accuracy rate for CASIA database of identification phase

five sets were taken, the size of each set was 15 palmprint templates. These samples belong to the same samples stored in the database. To calculate the FAR, samples of five sets were taken, the size of each set was 15 palmprint templates. These samples were of out the stored database. Finally, accuracy rate was calculated based on FRR and FAR as: Accuracy = (100 − (FRR + FAR)/2).

According to the results in Table 85.3, it was observable that the highest accuracy was at set no. 3, 4 and 5, with a value of 100 %. The results had the highest FRR, which was 6.66 %, which means, just one palmprint of the fifteen valid users was rejected, and with the same high rate (6.66 %) of the FAR, means that one of fifteen invalid palmprints was accepted. The accuracy rate is 98 % (Fig. 85.7).

85.4 Conclusion

All methods used in this study are based on important steps in the processing and recognizing of palmprints. The major important steps include preprocessing, feature extraction, and matching. All of the aforementioned processes were carried out in a variety of ways and algorithms, which are suitable for the structural condition of the image itself. The results of the experiment show that the overall goal of using invariant moments on the basis of the wavelet transform is successfully implemented on palmprints. It was found that moments of extracting palmprint to be invariant to rotation, translation and scaling. Transformation was applied to decompose palmprint images, that made moments more stable implemented to achieve its goal.

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