Preprocessing algorithm for palm image alignment acquired in touchless biometric system

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Abstract

Touchless palm print and palm vein biometric systems are secure from spoof attacks. These systems acquire images with less constraints and have to be subjected to preprocessing stages. There challenges for aligning palm images during preprocessing. This paper presents an algorithm for alignment of palm images in vertical direction. The effectiveness of the alignment is also evaluated in the paper.

Keywords: biometric systems, touchless, alignment, preprocessing, effectiveness

1. Introduction

Biometric identification or verification systems are based on human biological features which cannot be lost, stolen or forged. They can be used to confirm the identity of a person or to detect imposter [1, 2]. Biometric systems are automated systems used in security applications [3].

Palmprints are stable and unique; have a much larger surface area and many features [4]. Every individual also has unique and stable structure of veins underneath the human skin which cannot be tampered with and can be acquired using near infrared illumination [5]. The biometric system becomes safe from spoof attacks [6,7].

Contact free acquisition systems are preferred so that user does not touch the surface of the sensor [8]. The position and alignment of the person's hand pose difficulties in feature extraction and matching [9]. This makes it necessary to use appropriate preprocessing to align the palm in the image.

2. Basic Information

Pre-processing is carried out for segmentation, alignment, contrast enhancement and increasing the sharpness of the images so that the features become dominant and can be easily extracted [10]. This paper focuses on correctness in image alignment.

To start with, thresholding is used for image segmentation. The threshold value can be predefined or determined by Otsu or Savuola methods [11]. The palm print images have to be aligned to have same orientation. The binarised shape of the hand can be approximated by an ellipse. The parameters of best-fitting ellipse are used to determine the required angle of rotation of the image for alignment [12]. Similarly, the longest line in a palm which passes through the middle finger, minutia points or four nearest points from the centre have also been used for alignment [13-14].

Palm acquisition is either touch based or touchless. A touch based setup may either have pegs to ensure desired position of hand placement or may be peg free with fewer constraints on hand placement. Preprocessing is required to locate correct position of the palm [15]. Touchless setups introduce of more degrees of freedom in hand images, rotation, pose variation and scale change. Preprocessing becomes necessary to overcome these problems [16].

3. Methodology

The study is undertaken on images from standard databases of IITD and CASIA. Some images have been acquired in the laboratory using Logitech web camera. Images are selected such that they have varied orientations over 360°. The experimental work is explained in section 4. The results obtained and discussion are included in section 5.

4. Experimental Work

Preprocessing operations are performed to segment the palm from the background followed by palm alignment. The alignment is undertaken in two steps- coarse alignment followed by fine alignment.

4.1. Palm Segmentation

The Palm segmentation process begins with converting colour image to gray scale image, applying a low pass filter and adjust for illumination effects. The images from the standard databases are grayscale images and conversion to gray scale was not required. However, for images acquired with web camera, preprocessing to convert colour images to gray scale images has been included.

In case of palm images, the acquired images not only have hand with palm and fingers, but also have some background. Segmentation is essential to separate the palm from the background. The processing stages incorporated for segmenting the hand is binarising the image, filling the holes, eliminating small objects and boundary detection. Converting an image to binary is achieved with gray level global threshold by Otsu's method. Some binary images are found to have holes which have been filled by using two dimensional four connected neighborhood. Morphological processing has been used to eliminate the small regions in the background and retain only the palm region. The final step is to obtain the boundary of the palm and retain the image inside the boundary.

4.2. Palm image coarse alignment

A preprocessing technique has been developed to deal with the variations in touchless setup, which allows the palm to be facing the sensor in any orientation. The algorithm for alignment determines the angle to rotate the palm image such that the resulting image has the palm's outer edge in the vertical direction with fingers in the upwards direction. The algorithm is simple and works in two stages. The first stage deals with coarse alignment and orients the image in the vertical direction with fingers upwards. The second stage deals with the fine alignment of the image based on the outer edge of the palm.

In MATLAB, the orientation of a region is the angle ranging from -90 to 90 degrees between X axis and the major axis of best fitting eclipse for that region. To determine the general orientations of palm images in the vertical direction, many images were selected randomly from IITD database and their orientations determined. Some of the images from the database and their orientation are given in table 1.

Table 1. Palm images and their orientations

Images						
Orientation	-86.6º	-83.4º	-86.4º	86.3º	-86.1º	84.8º

Considering their orientations, it was assumed that for palm images in the vertical direction, the orientation is around ±85º. Hence in the alignment algorithm proposed in this work, the acquired palm images have been rotated to have final orientation of ±85º.

Figure 1 shows examples of images from CASIA database after being rotated to have orientation of ±85º

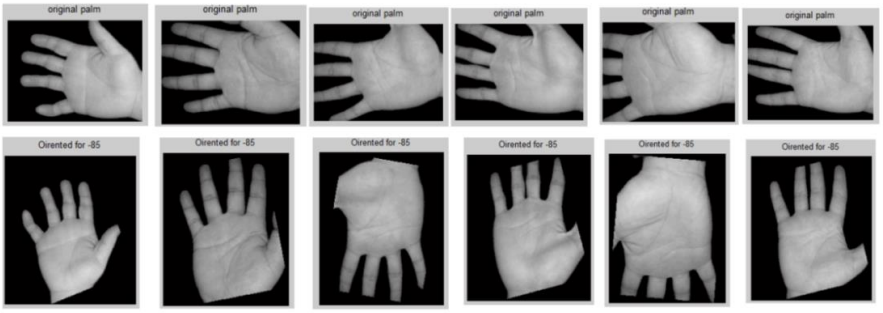


Figure 1. Effect of rotating palm images in CASIA database for orientation of ±85º

It is observed that, the rotated palm images are vertical, but in some cases the fingers point in the downwards direction while in others in the upwards direction. In order to maintain uniformity in the position of fingers across all images, it was decided to keep the fingers in the upwards direction. Steps are included in preprocessing to determine whether the fingers are pointed upwards or downwards. In case the fingers are found to be in the down part, then the image is rotated by 180°.

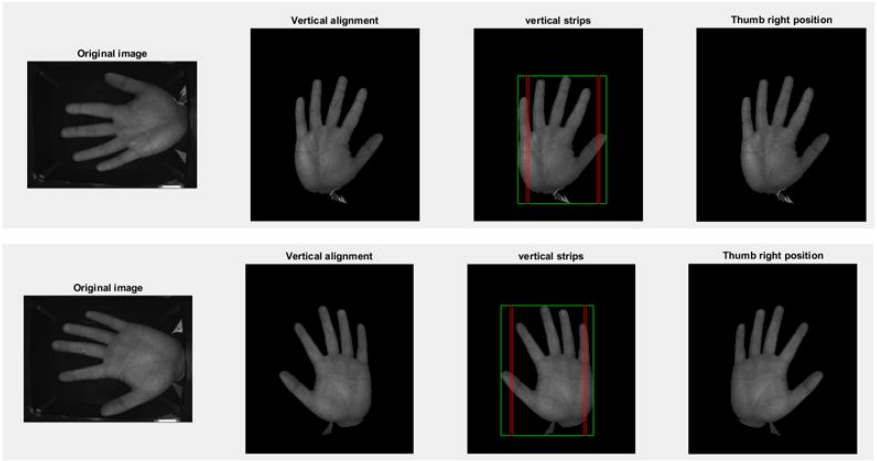


Figure 2. Preprocessing for coarse alignment

The algorithm for alignment also detects the position of the thumb and orients the image such that the thumb is on the right side in the image. This procedure for two sample images from CASIA database is shown in the figure 2.

4.2. Palm image Fine alignment

During fine alignment, the outer edge of the palm has to be made exactly vertical. In order to achieve this, first the bounding box of the image which specifies the coordinates of the corner point and the width and height of the palm region has been found. Two offset points have been considered with respect to the height of the box such that they lie on the edge of the palm. The slope of an imaginary line connecting these points has been calculated and this slope has been used further to rotate the image with an angle so as to make the line parallel to y axis.

Figure 3 shows complete sequence of preprocessing implemented for alignment.

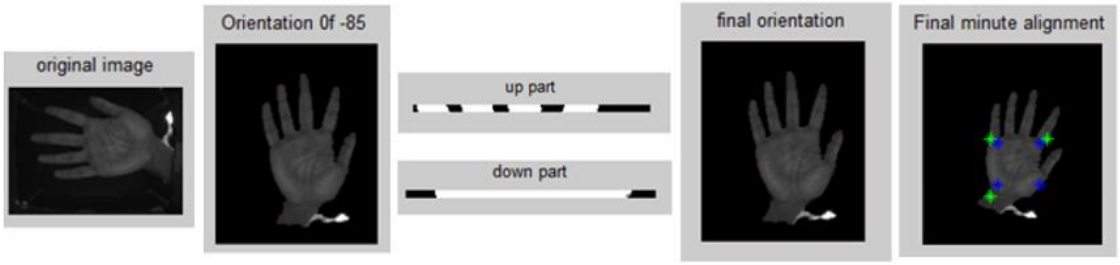
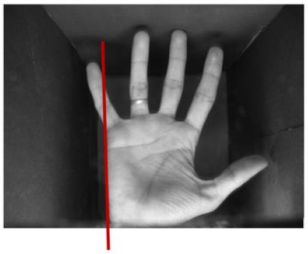


Figure 3: Preprocessing for fine alignment

4.2. Evaluating effectiveness of alignment algorithm

The algorithm has been tested on images from IITD, CASIA Palmprint and Multispectral databases as well as on images acquired using Logitech web camera. The effectiveness is evaluated by determining the direction deviation. Figure 4 (i) shows an example of edge of palm perfectly parallel to y axis. Figure 4 (ii) shows the edge slightly inclined. The angle through which the edge is inclined with reference to reference points is referred as direction deviation [17].



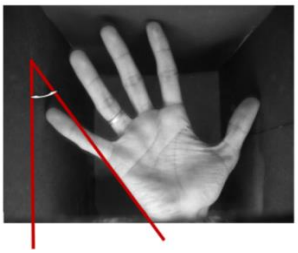


Figure 4 (i) Edge parallel to y axis (ii) Edge at an angle with y axis

To test fine alignment processing in the proposed algorithm, direction deviation has been computed before and after fine alignment.

5. Result and Discussion

The experimental results obtained for two images from each database are shown in table 2. It is observed that all the images under study have been appropriately aligned.

Table 2. Effectiveness of alignment algorithm

Database	Image	Initial orientation	Angle for ± 85	Orientation after vertical alignment	Angle for fingers up	Orientation after fingers up	Direction deviation before fine alignment	Direction deviation after fine alignment
IITD Database	1	-66.5	-18.5	-85.0	180	-85.0	12.5	-1.3
	2	-72.6	-12.4	-85.0	0	-85.0	-9.7	0
CASIA Palmprint Database	1	-4.1	-80.9	-84.9	0	-84.9	-5.7	-0.6
	2	2.4	82.6	85.0	180	85.0	4.0	1.2
CASIA Multi-spectral Database (Palmprint images)	1	-6.9	-78.1	-85.0	0	-85.0	-21.6	1.8
	2	7.8	77.2	84.9	180	84.9	3.0	0
CASIA Multi-spectral Database (Palm Vein images)	1	-2.2	-82.8	-85.0	0	-85.0	-8.7	-0.6
	2	11.6	73.4	85.0	180	85.0	1.2	0.6
Images with Logitech web camera	1	-33.0	-52.0	-85.0	180	-85.0	4.1	0
	2	-76.5	-17.5	-84.9	180	-84.9	-2.6	0.8

To ensure the effectiveness of the alignment method, a total of 330 different images are tested and the results obtained are given in the table 3. The 330 images selected for testing the algorithm had initial orientation varying over 180°.

Table 3. Evaluating alignment over different database images

Database	Number of images tested	Range of angle for rotation	Absolute Range of Orientation after coarse alignment	Absolute Average of Direction deviation before fine alignment	Absolute Average of Direction deviation after fine alignment
IITD database	50	-35.1 to 15.7	84.94 to 85.02	9.7	7.0
CASIA Palmprint Database	80	-84.7 to 84.3	84.98 to 85.01	4.8	1.5
CASIA Multi-spectral Database (WHT images)	60	-84.8 to 84.5	84.98 to 85.01	7.9	3.6
CASIA Multi-spectral Database (940nm images)	60	-84.8 to 84.9	84.98 to 85.01	14.4	7.0
Images taken with Logitech web camera	80	-52.0 to 50.0	84.94 to 85.03	8.7	1.9
In Total	330	-84.8 to 84.9	84.94 to 85.03	8.8	3.8

The coarse alignment algorithm of orienting the palm in ±85° is observed to produce the desired results. The fine alignment algorithm is having overall direction deviation of 3.8°. Moreover the direction deviation for images taken with a web camera in the laboratory is low at 1.9°. Hence it is verified that the proposed algorithm is efficient within acceptable limits.

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