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# An optimized palmprint recognition approach based on image sharpness

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ABSTRACT

Biometric identification is an essential field in biometric security. The preprocessing of a palmprint image is essential to the recognition performance. Most researchers use clear palmprint images for recognition and consider that the higher is the image sharpness, the better is the performance. However, we found that the performance of palmprint recognition can be improved by using low sharpness images, as long as the sharpness is within a range which we call optimal range. In this paper, the method of evaluating the palmprint image sharpness is introduced and an approach of changing the image sharpness to the optimal range is proposed. When all the images are tuned to this optimal range, the palmprint recognition performance can be significantly improved. Experiments were conducted on the PolyU Palmprint Database and IIT Delhi using CompCode and POC to validate the proposed approach and find the optimal range. The experimental results show that the proposed approach can improve palmprint recognition performance by 15%.



## 1. Introduction

As the demand of high security increases, biometric identification, like fingerprint, palmprint and iris identification, has become the most popular technology among all the identification methods. Many smartphone manufactories have embedded the fingerprint recognition sensor into their products, such as iPhone 6 and Huawei Mate 7, providing a secure way of personal identification when users want to access the phone, login an account or settle an online payment. Fingerprint recognition has been used for a long time and proves to be a successful solution to security problems. However, there is limitation for fingerprint recognition system due to its unsatisfactory ability to avoid fake fingers [1] and the hygiene problem during image acquisition. Iris recognition is a reliable technology with high accuracy and excellent anti-spoofing ability. However, the cost of iris recognition system is too high and the system is not easily accepted by users because of the uncomfortable acquisition of iris images [3–6,15]. In recent years, since its high accuracy of recognition, palmprint recognition has received widely attention and now is a promising solution to security issues in many situations. To achieve better performance of a palmprint recognition system, different methods have been designed, using different patterns like patterns of ridges, minutiae, valleys, principal lines and wrinkles.Palmprints can provide multi-spectral features [20,26] which can improve the recognition accuracy and also avoid fake palmprints. The reasons why palmprint recognition systems have not yet been widely used are that their physical size is too large and that fingerprint identification systems have been well used for many years in the market [11]. However, compared with iris and fingerprint, though the touch-based palmprint identification system requires part of the palm touching the acquisition device, the center of the palm, where the palmprint is located, would not touch the device and therefore the palmprint is less possible to be copied by others. Moreover, researchers are working on touchless palmprint identification systems [7], making it more secure and hygeian. Last but not the least, using multi-spectral palmprint images [20] can significantly improve the system's anti-spoofing capability because it is difficult to know which spectrum the acquisition system is using.

According to a study [28] which compares the performance of different methods of palmprint recognition, the method CompCode is the best choice for palmprint recognition when all these factors are taken into consideration: accuracy, computational complexity, memory complexity and template size. Other methods like Binary Orientation Co-occurrence Vector [8] may achieve higher accuracy but increase the computational complexity to a great degree, which results in much more consumption of time and therefore is difficult to be used in practice.

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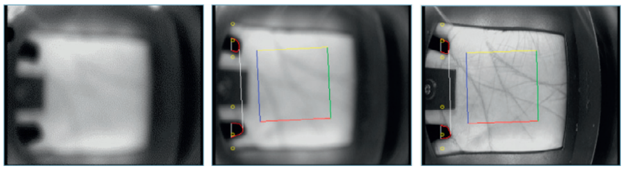


**Fig. 1.** (a) Image out of focus, (b) image out of focus but principal lines of the palm can still be extracted, (c) image in focus.

CompCode was first introduced by Zhang et al. [27] and then developed to a practical solution for real-time palmprint verification [14]. Generally, palmprint recognition includes four main stages: image acquisition, image processing, feature extraction, pattern recognition. In the image processing stage, the region of interest (ROI) is defined and located. The palmprint features in Zhang et al. [27] use Gabor features extracted from the ROI by 2-D Gabor filters. The responses of 2-D Gabor filters are sensitive to the sharpness of the ROI. A defocused palmprint image usually appears that the palm lines are blurry so the extracted Gabor features are totally different from those extracted from a focused palmprint image. Therefore, palmprint image quality assessment is necessary during palmprint identification. In this paper, different palmprint image assessment methods are tested and Edge Acutance Value (EAV) is proved to be the best one among them. Using EAV to evaluate the image quality can estimate the image sharpness. In another experiment where image sharpness are decreased by Gaussian filters, it is found that palmprint images with lower sharpness can perform better than clear images, as long as the lower sharpness is within a range. This result is quite different from other researchers' that enhancing the image sharpness can obtain better palmprint features [10,21]. Our experiment result indicates that changing image sharpness can improve the performance of palmprint recognition, For a clear palmprint image, it can be smoothened and provide better recognition result. For a blurry palmprint image, if the sharpness is lower than a normal value but still within a specific range, the image can be restored to higher sharpness and the restored images can go on for feature extraction. But if the sharpness is lower than a specific threshold, the blurry palmprint image is not appropriate for recognition and it should be discarded. To verify our experimental results, we also conducted palmprint recognition experiments using Palmprint Orientation Code (POC) [25] on PolyU Palmprint Database [22] and IIT Delhi Palmprint Image Database version 1.0 [9,17].

The rest of the paper is organized as follows. Section 2 summarizes the comparison among several image quality assessment algorithms and gives the reasons why EAV is selected. Section 3 presents the approach of smoothing and restoring palmprint image. Section 4 presents the experimental results and analyzes the proposed approach. Section 5 summarizes the motivation and contribution of this paper.

## 2. Palmprint image quality assessment

Image quality assessment is essential to biometric recognition. The quality of fingerprint and iris images usually have to be assessed whether they are good enough for feature extraction [2,12,19]. Since there are few articles discussing image quality assessment in palmprint recognition, we designed an experiment to testify that the quality of palmprint image affects ROI extraction and matching. Fig. 1 shows three palmprint images captured by the same device from the same palm under the same lighting condition but with different depths of camera focus. The experiment shows that: (a) the image fails in ROI extraction; (b) although the ROI of the image can be extracted correctly but the feature extracted fails to match that extracted from a clear image; (c) this is a standard palmprint image without blur that can provide high quality features for recognition.

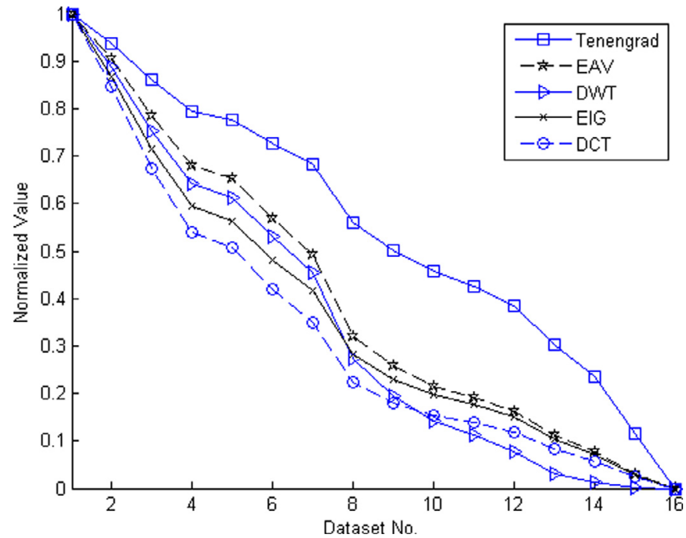


**Fig. 2.** Different methods to measure the image sharpness.

**Table 1**
Image sharpness measured by different methods.

| | EIG | DCT | EAV | DWT |
|---|---|---|---|---|
| Mean | $2.4812 \times 10^7$ | $3.7665 \times 10^6$ | 43.0357 | 0.5316 |
| Variance | $5.7836 \times 10^6$ | $9.2823 \times 10^5$ | 5.4351 | 0.1300 |
| Normalized variance | 0.233 | 0.246 | 0.126 | 0.245 |

There are many methods to measure the image sharpness: Tenengrad [16], EIG (Energy of Image Gradient) [23], DCT (Discrete Cosine Transform) [18], EAV [24] and DWT (Discrete Wavelet Transform) [13]. These methods are tested on 16 palmprint datasets. These 16 datasets are generated from one dataset by Gaussian filters with different parameters. The No. 1 dataset consists of clear images. As the No. of the dataset increases, the average sharpness of it decreases. The results are normalized to [0, 1] and shown in Fig. 2. EIG, DCT, EAV and DWT have similar sensitivity while the sensitivity of Tenengrad is much lower. Table 1 shows the mean and variance of sharpness calculated by EIG, DCT, EAV and DWT tested on PolyU Palmprint Database [22]. The normalized variance indicates the stability of the method. Low normalized variance means the method has good performance in stability.

In our experiment, the Edge Acutance Value (EAV) was used to evaluate the quality of a palmprint image because EAV has high sensitivity and stability. EAV is defined as follows to calculate the sharpness value of an image *I*.

$$EAV(I) = \frac{\sum_{x=1}^{m}\sum_{y=1}^{n} Neighbor(x,y)}{m \times n} \tag{1}$$

where

$$Neighbor(x,y) = \sum_{i}\sum_{j} \frac{|I(x,y) - I(i,j)|}{\sqrt{(x-i)^2 + (y-j)^2}} \tag{2}$$

$|x-i| \le 1,\ |y-j| \le 1,\ |x-i| + |y-j| > 0$, $I(x, y)$ is the value of pixel $(x, y)$ and $m$, $n$ denotes the number of rows and columns of image *I*.

A low EAV value means the sharpness of the image is low. Fig. 4 shows palmprint images with different sharpness and their corresponding EAVs are shown in Fig. 3. To measure the sharpness