DEGRADED PARTIAL PALMPRINT RECOGNITION FOR FORENSIC INVESTIGATIONS

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ABSTRACT

Palmprint trait is emerging as a new and practical biometric solution and a few systems using full palmprints have been proposed. However, partial palmprints left at scenes of crime have not yet been exploited to recognize and find crime suspects. In this paper, a modified well known algorithm, referred to as Modified Phase Only Correlation (MPOC) is proposed to match poor quality (degraded) partial palmprints left by suspects at crime scenes against a full palmprint registered in a template database. Instead of using the conventional peak as the matching score between two palmprint images, the ratio of the conventional peak to the highest peak in the outside-lobe correlation plane is employed. Experiments were conducted on a generated database of 800 partial palmprints having an area less than 25% of that of the full palmprint images from which blurred and degraded images were created by adding an intense synthetic Gaussian noise. The results show that the proposed method yields high recognition performance thus demonstrating its ability to tackle the problem of identifying low quality partial palmprint images giving an Equal Error Rate (EER) less than 0.4%.

Index Terms— Partial Palmprint, Phase Only Correlation, Identification

1. INTRODUCTION

Palmprint biometrics deals with automatically recognizing individuals based on their unique palms features, such as the principal lines, wrinkles, ridges, minutiae points, singular points and texture, etc. Extensive work has been carried out on full to full palmprint matching using a low resolution palmprint images of less than 150 dpi for commercial applications such as access control [1][2][3] [4][5]. The advantages of using low resolution images are usage of low cost sensor and less memory space as well as low computational complexity leading to real-time performance. On the other hand, using high resolution images (500dpi) in this context has been received little attention [6][7]. However, to the best of our knowledge only [7] has discussed the problem of using palmprint for forensic investigation and law enforcement to identify crime suspects by stating that crime statistics shows that 25% of crime scenes contain only partial palmprints [7]. One of the most challenging factors behind using partial palmprint images to automatically recognize a suspect depends on the accuracy of the matching decision and the poor quality of the recovered noisy partial palmprints left at the crime scene. A partial to full palmprint matching system has been proposed in [7] and uses the concept of Scale Invariant Feature Transform (SIFT) and minutiae features at the matching process. However, the limitations of this system are (i) the minutiae extraction is very difficult in poor quality noisy images, (ii) the huge number of SIFT keypoints (around 15,000 in small partial palmprint) make the matching not practical and very complex, and (iii) poor quality noisy palmprint images were not used in the evaluation of the algorithm.

In this paper a modified POC based noisy partial to full palmprint recognition technique is proposed to address the problem of matching noisy partial palmprint images. POC is an image matching technique using only the phase components of 2D Discrete Fourier Transforms (DFTs) of given partial palmprint images. This technique was successfully applied to fingerprint and iris recognition [8][9]. The contribution of this paper is to demonstrate that this matching technique can be modified to be highly effective for noisy partial to full palmprint recognition.

The remainder of this paper is organized as follows: Section 2 gives a brief fundamental theory of the POC technique while section 3 and section 4 detail some properties and the modified POC. Experimental results are given in section 5. Finally, a conclusion is drawn in section 6.

2. PHASE ONLY CORRELATION (POC): AN OVERVIEW

In the Fourier transform domain, the phase has been shown to be more informative than the spectrum [8][10]. This section introduces the fundamental theory of phase based image matching using the Phase Only Correlation.

Let us consider two palmprint images $f_1(x, y)$ and $f_2(x, y)$ with $F_1(u, v) = A_1(u, v)e^{j\theta_1(u,v)}$ and $F_2(u, v) = A_2(u, v)e^{j\theta_2(u,v)}$ are their corresponding Fourier transforms, respectively, where $A_{1,2}(u, v)$ and $\theta_{1,2}(u, v)$ are the amplitude and phase components, respectively. The Phase Only

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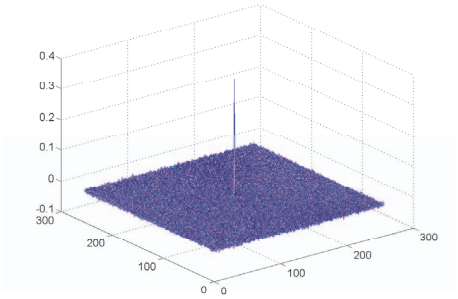


Fig. 1. POC between identical full and partial palmprint images

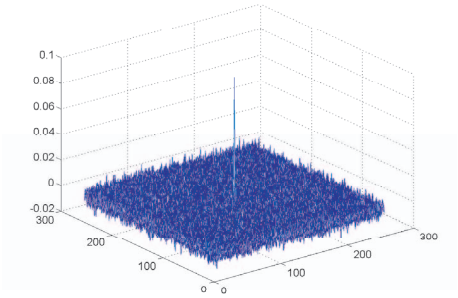


Fig. 2. POC between identical clean full and noisy partial palmprint images

Correlation function $r_{f_1 f_2}(x, y)$ of the two palmprint images is given as follows:

$$r_{f_1 f_2}(x, y) = \varphi^{-1}\{\frac{F_1(u, v) \cdot F_2^*(u, v)}{|F_1(u, v) \cdot F_2^*(u, v)|}\} \quad (1)$$

$$= \varphi^{-1}\{e^{j(\theta_1(u,v)-\theta_2(u,v))}\} \quad (2)$$

where φ^{-1} denotes the inverse of Fourier transform and $F_2^*(u, v)$ is the complex conjugate of $F_2(u, v)$. If the two palmprint images are similar, their POC function would produce a distinct sharp peak in the origin. On the other hand, if the two palmprint images are not similar, the peak value drops significantly. Therefore, the amplitude of this peak can be used as an efficient similarity measure for palmprint image matching.

3. TRANSLATION AND ILLUMINATION INVARIANCE OF THE POC METHOD

The most remarkable properties of the POC are (i) invariance to image translation, (ii) invariance to illumination change, and (iii) immunity against additional noise.

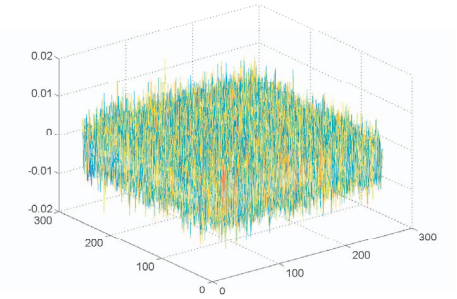


Fig. 3. POC between identical full and partial different palmprint images

Let us consider $f_3(x, y)$ the shifted and scaled image of $f_2(x, y)$ by (x_0, y_0) and β, respectively. Therefore $f_3(x, y)$ can be written in terms of $f_2(x, y)$ as follows:

$$f_3(x, y) = \beta f_2(x - x_0, y - y_0) \quad (3)$$

By applying the Fourier transform to Equation (3) the following can be obtained :

$$F_3(u, v) = \beta e^{-j2\pi(x_0 u - y_0 v)} F_2(u, v) \quad (4)$$

From Equation (5) and Equation (4), the POC function between $f_1(x, y)$ and $f_3(x, y)$ can be written as:

$$r_{f_1 f_3}(x, y) = \varphi^{-1}\{e^{-j2\pi(x_0 u - y_0 v)} e^{j(\theta_1(u,v)-\theta_2(u,v))}\} \quad (5)$$

$$= r_{f_1 f_2}(x - x_0, y - y_0) \quad (6)$$

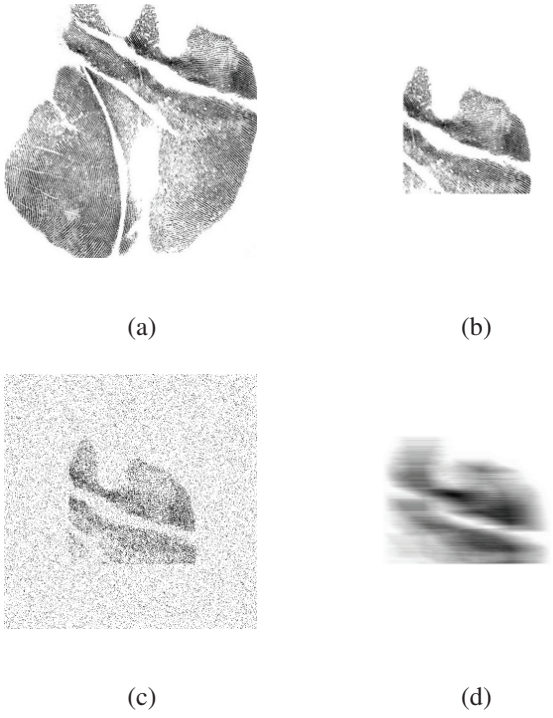
The above equation shows that the correlation peak is shifted by (x_0, y_0) and its value is invariant to translation and illumination changes. Fig.2 shows the noise immunity of the POC where the POC is calculated between a clean full palmprint image and a partial palmprint images corrupted with Gaussian noise with zero mean and a standard deviation of 40. As it can be seen. although the value of the correlation peak decreases it is still discriminative.

4. PROPOSED MODIFIED PHASE ONLY CORRELATION (MPOC)

When using POC method the correlation peak value decreases when the noise energy increase relatively without changing its shape and location [8]. To enhance the discrimination of the correlation peak and hence improve its immunity against noise, an alternative but simple new peak measure is proposed in this work. The new peak value $nr_{f_1 f_2}(x, y)$ is determined as the ratio of the main peak inside-lobe of 11×11 pixel size at the origin to the highest peak in the remaining Outside-lobe correlation plane as follows:

$$nr_{f_1 f_2}(x, y) = \frac{\arg\max(r_{f_1 f_2}(x, y))}{\arg\max(\text{Outside-lobe})} \quad (7)$$

The main idea behind using the highest peak of the Outside-lobe in equation (7) is to augment the reliability of the peak discrimination, since the Outside-lobe correlation plane maintains flat, approximately flat and spurious peaks in the three following different matching scenarios, respectively: (i) two identical palmprint images (clean partial and clean full) (ii) two identical palmprint images (noisy partial and clean full) (iii) two different palmprint images (clean partial and clean full) palmprint are matched as can be seen in figures (1,2 and 3). Therefore, the use of equation (7) ensures the maximization of the correlation peak in the genuine matching case (divide by small value) though it marginally affects it in the imposter matching case (divide by same value range).



(a) (b)

(c) (d)

Fig. 4. Partial palmprint samples (a) Full Palmprint, (b) Partial palmprint, (c) Same partial palmprint corrupted with Gaussian noise , (d) Same partial palmprint blurred horizontally

5. EXPERIMENTAL RESULTS

All the experiments are carried out on generated database collected using a live scan scanner. 200 full palmprint have been captured from 100 persons. Each person has been asked to provide two images of his right and left hand. The images have been taken without any control such as illumination variation, position and noise. Originally, the collected images were of size (2500×2500). However, only the palm area was considered in the processing. Consequently, the size of all the images used in the following experiments was reduced to 1024×1024 with 500 dpi resolution. The partial palmprint images were generated from the full palmprint images by cropping its quarters. The majority of the quarters represent less than 25% of the full palmprint area. Two test sets have been used in the evaluation of the proposed approach. The first set contains 800 quarters palmprint corrupted by Gaussian noise of zero mean and standard deviation of 0.04 as shown in Fig4(c). The second set contains 800 quarters palmprint blurred horizontally and vertically with a motion of 22 pixels length as shown in Fig4(d). Two different experiments have been carried on each test set. A matching is considered correct if the matched partial and full palmprint are found to originate from same individual, otherwise it is considered incorrect. A total of 160,000 (200×800) matchings have been performed on each test set. The number of comparisons having a correct matching is 800 and the remaining are incorrect. False Acceptance Rate (FAR), False Rejection Rate (FAR) and EER are used to measure the system performance.

Figure(5.(a)) depicts the genuine and imposter similarity distribution using the first test set, as can be seen, both distributions are very well separated. The Receiver Operating Characteristics (ROC) curve is also depicted in figure (5.(b)) which is the plot of the FAR and FRR against all possible operating points. The curve clearly shows that the proposed technique performs very well, giving an EER (FAR = FRR) of 0.38% which is clearly very attractive result. The same experiment was conducted on the second test set. Figure(6.(a)) and Figure(6.(b)) depict the similarity distributions and the ROC curve, respectively. An EER of 0.03% has been obtained achieving very low error and high Genuine Acceptance Rate (GAR) (GAR = 1-FRR) of about 100%.

The results fairly show the robustness of the proposed technique in tackling the problem faced by crime scene investigators in order to match the left low quality partial palmprint at crime scene to a reference database.

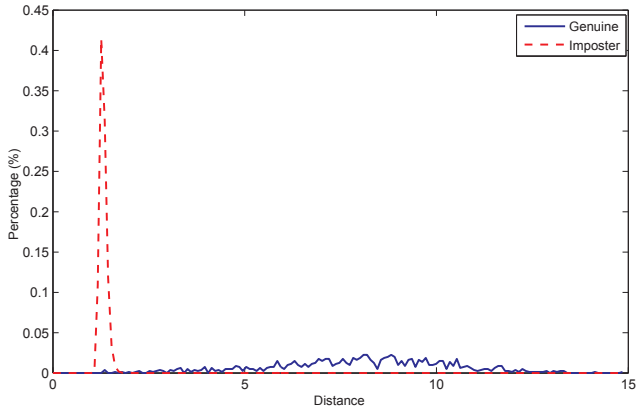
6. CONCLUSION

This paper proposed an efficient partial to full palmprint recognition which is not yet exploited by researchers. A MPOC has been used to match low quality partial palmprint images to the full once registered in reference database. The proposed method yields an outstanding performance and shows high robustness against additive noise and image blurring.

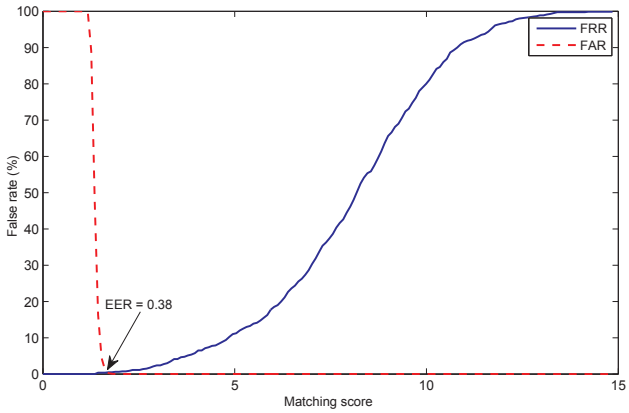
7. REFERENCES

[1] Wei Jia, De-Shuang Huang, and David Zhang, "Palmprint verification based on robust line orientation code," *Pattern Recogn.*, vol. 41, no. 5, pp. 1521–1530, 2008.

[2] David Zhang, Wai-Kin Kong, Jane You, and Michael

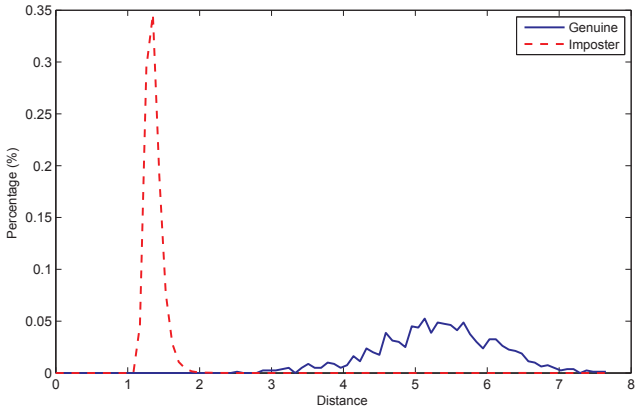


(a)

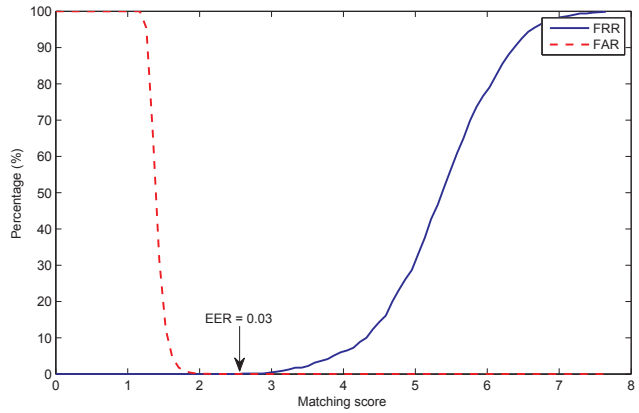


(b)

Fig. 5. (a) Genuine and Imposter distribution corresponding to the test set corrupted by Gaussian noise of zero mean and standard deviation of 40, (b) Corresponding ROC curve



(a)



(b)

Fig. 6. (a) Genuine and Imposter distribution corresponding to the blurred test set, (b) Corresponding ROC curve

Wong, "Online palmprint identification," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 25, no. 9, pp. 1041–1050, 2003.

[3] Adams Kong, David Zhang, and Mohamed Kamel, "Palmprint identification using feature-level fusion," *Pattern Recogn.*, vol. 39, no. 3, pp. 478–487, 2006.

[4] Xiangqian Wu, David Zhang, and Kuanquan Wang, "Fisherpalms based palmprint recognition," *Pattern Recogn. Lett.*, vol. 24, no. 15, pp. 2829–2838, 2003.

[5] Guangming Lu, David Zhang, and Kuanquan Wang, "Palmprint recognition using eigenpalms features," *Pattern Recogn. Lett.*, vol. 24, no. 9-10, pp. 1463–1467, 2003.

[6] Nicolae Duta, Anil K. Jain, and Kanti V. Mardia, "Matching of palmprints," *Pattern Recogn. Lett.*, vol. 23, no. 4, pp. 477–485, 2002.

[7] Anil Jain and Meltem Demirkus, "On latent palmprint matching," Tech. Rep. 48824, Matching state University, may 2008.

[8] Koichi Ito, Hiroshi Nakajima, Koji Kobayashi, and Tatsuo Higuchi, "A fingerprint matching algorithm using phase-only correlation," *IEICE Trans. Fundamentals.*, vol. 87-A, no. 3, pp. 682–691, 2004.

[9] Kazuyuki Miyazawa, Koichi Ito, Takafumi Aoki, Koji Kobayashi, and Hiroshi Nakajima, "An effective approach for iris recognition using phase-based image matching," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 30, no. 10, pp. 1741–1756, 2008.

[10] Xuelei (Sherry) Ni and Xiaoming Huo, "Statistical interpretation of the importance of phase information in signal and image reconstruction," *Statistics & Probability Letters*, vol. 77, no. 4, pp. 447–454, February 2007.