Study and comparison of various point based feature extraction methods in palmprint authentication system

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Abstract

Biometrics is the word derived from Greek words "Bio" means (life) & "Metrics" means (to measure). Biometrics is the science of measuring human characteristics for the purpose of authenticating or identifying the identity of an individual. Biometrics System is used for automated recognition of an individual. In Information system in particular biometrics is used as a form of identity access management and access control. It is also used to identify individuals in groups that are under surveillance. In this paper, palmprint biometric is used for personal authentication. Various feature extraction methods to be discussed and compared are Forstner operator, SUSAN operator, Wavelet based salient point detection and Trajkovic and Hedley corner detector.

Keywords: Biometric, Corner, Palmprint, Palmprint features.

1. Introduction

The palmprint of a person can be also taken as a biometric. It is a physiological biometrics, palmprint, the inner part of a person's hand, below the fingers to the wrist meets out both the theoretical and practical requirements to be a biometric. Palmprint is universal because every person has palmprint. It is unique because every palmprint is different from other person palmprint even identical twins have different palmprint features. Palmprint is permanent or inseparable from individual as compared to identification items. It is easy to collect and consistent because it does not change much with time. It performs better in term of accuracy, speed and robustness. Palmprint biometric system is more acceptable by public because users can gain access anytime they want without being monitored by a surveillance camera. It is hard to imitate because of its size.

Palmprint is features rich. It consists of geometry features, point features, line features, texture features and statistical features. Palmprint point features are datum points, line intersection points, end line points etc. Point features can be obtained through high resolution palmprint image. In this paper, several point (corner) based feature extraction methods are studied and compared. Results of various feature extraction methods are compared and among them best method is found out.

2. Corner based feature extraction methods

Corners are the points where intensity changes in all directions. In palmprint, palmprint features can be of the form of corner points. These features can be extracted using Forstner operator, SUSAN operator etc. These methods are discussed in detail as follows:

2.1 Förstner Operator

The Förstner Operator developed by Förstner and Gülch in 1987 has been widely adopted in photogrammetry and computer vision over the last two decades. The aim of developing this operator is to create a fast operator for the detection and precise location of distinct points, corners and centres of circular image features. The algorithm identifies interest points, edges and regions using the autocorrelation function A. The derivatives of A are computed and summed over a Gaussian window. Error ellipses are computed and based on the size and shape properties of each ellipse, the interest points found are classified as points, edges or regions. Förstner calculates the size and shape of the error ellipses using two eigenvalues $\lambda 1$ and $\lambda 2$ as well as the inversion of A.

The error ellipse size is determined by:

$$w = \frac{1}{\lambda_1 + \lambda_2} = \frac{\det(A)}{trace(A)}, \quad w > 0$$

The roundness of the ellipse is determined by:

$$q = 1-\left(\frac{\lambda_1-\lambda_2}{\lambda_1+\lambda_2}\right)^2 = \frac{4.\det(A)}{trace(A)^2}, \quad 0 \le q \le 1$$

The algorithm classifies each area based on the values of w and q.

- Small circular ellipses define a salient point
- Elongated error ellipses suggest a straight edge
- Large ellipses mark a homogeneous area

  Practically Förstner operator has few limitations like high computational cost, relatively slow and impractical for high-level data analysis.

2.2 SUSAN Operator

The SUSAN operator was developed by Smith and Brady (1997) for image processing. It is an edge and corner detector method which is accurate, noise resistant and fast. It is better as compared to other operators and overcome maximum problems faced by other methods, such as high computation time. The SUSAN operator is based on the concept that each point of interest in the image will have associated with it a local area of similar brightness values and that these areas can be used as a guide to help find features of interest such as corners and edges in the image. The SUSAN operator finds areas of similar brightness, and consequently for interest points within a weighted circular window. The central pixel in the search window is denoted as the nucleus. The area within the window that has similar intensity values to the nucleus is computed and referred to as the USAN (Univalue Segment Assimilating Nucleus). A low value for the USAN indicates a corner since the central pixel would be very different from its surroundings. After assessing results and eliminating outliers, the local minima of the SUSANs (smallest USAN) remain as valid interest points. The comparison between pixel brightness values is computed using the following equation:

$$o(\vec{p}, \vec{p_0}) = \begin{cases} 1 \;\; if \;\; \left|I(\vec{p}) - I(\vec{p_0})\right| \le t_b \\ 0 \;\; if \;\; \left|I(\vec{p}) - I(\vec{p_0})\right| > t_b \end{cases}$$

where, $\vec{p_0}$ is the position of the nucleus in the two-dimensional image, $\vec{p}$ is the position of any other point within the circular window, I($\vec{p}$) is the brightness value of any pixel, t_b is the brightness value threshold and *o* is the output of the comparison. The comparison is calculated for each pixel in the circular window and the total number of pixels with similar brightness values as the nucleus is summarized as:

$$n(\vec{p_0}) = \sum_{\vec{p}} o(\vec{p}, \vec{p_0})$$

N($\vec{p_0}$) value is compared with a geometric threshold, g. The algorithm uses a threshold value in order to distinguish between features that make suitable interest points and non-suitable features. To find a corner in the image, the threshold value g is set to half of the maximum value of N($\vec{p_0}$), n_{max}. If $n_{max} < g$ then it indicates corner existence.

2.3 Wavelet based salient point detection

The wavelet transform is a multi-resolution representation of image variations at different scales. A wavelet is an oscillating and attenuated function. It is known that wavelet representation gives information about the variations in the signal at different scales. The aim is to extract salient points from the image where there is some variation in the signal at any resolution. A high wavelet coefficient at a coarse resolution corresponds to a region with high global variations. A relevant point is found out to represent this global variation by looking at wavelet coefficients at finer resolutions.

The coefficient represents 2p signal points. To select a salient point from this tracking, among these 2p points the one with the highest gradient is chosen. Saliency value is set as the sum of the absolute value of the wavelet coefficients in the track:

$$saliency = \sum_{k=1}^{-j} \left| C^{(k)}(W_{2^j} f(n)) \right|, 0 \le n < 2^j N, -\log_2 N \le j \le -1$$

where, $C(W_{2^j} f(n))$ is the wavelet coefficient, N is the length of the signal.

The tracked point and its saliency value are computed for every wavelet coefficient. A point related to a global variation has a high saliency value, since the coarse wavelet coefficients contribute to it. A finer variation also leads to an extracted point, but with a lower saliency value. The saliency value is thresholded, in relation to the desired number of salient points. The points related to global variations; local variations are obtained. The salient points extracted depend on the wavelet used.

2.4 Trajkovic and Hedley corner detector

Trajkovic and Hedley corner operator was developed by Miroslav Trajkovic and Mark Hedley in 1998. The operator is compared with other operators like Plessey operator etc and found that operator has slightly inferior repeatability rate, but the localization is comparable and improved on junctions. Trajkovic and Hedley proved empirically that their operator is five times faster than the Plessey operator and at least three times faster than all of the operators considered. Being fast method, the computation time is less. This operator is suitable for real-time applications because of minimal computational demands.

The cornerness measurement of Trajkovic operator is calculated by considering a small circular window and all the lines which pass through the center of the circle. Center of the circle is denoted by *C* and an arbitrary line that passes through *C* and intersects the boundary of the circular window at *P* and *P'*. Intensity at a point X is denoted by I_X and is summarized in Figure 1.

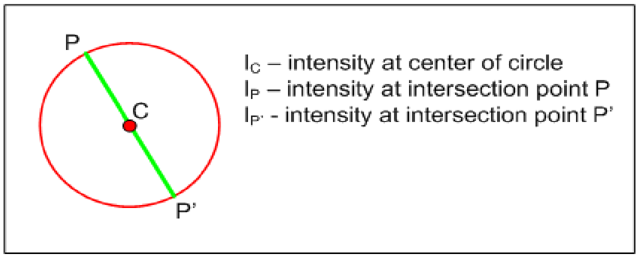

Figure 1: Notation for Trajkovic Operator

The cornerness measure for the Trajkovic operator is then given as:

$$C(x,y) = \min\left((I_P - I_C)^2 + (I_{P'} - I_C)^2\right), \forall_{P,P'}$$

Different cases are studied to understand the cornerness measurement.

- *Interior Region* – it is clear from figure 2 for interior region that the majority of the circular window is within an interior region (i.e. region of near uniform colour) there will be at least one line where the intensity at the center of the circle I_C is approximately equal to I_P and $I_{P'}$. it is illustrated by the green lines in Figure 4.1, there is in general several lines where I_C is approximately equal to both I_P and $I_{P'}$. It concludes that cornerness measure will be low and robust to noise.
- *Edge* - for the case where the center of circle lies just on an edge there will be exactly one line, shown in green, where I_C is approximately equal to both I_P and $I_{P'}$. Since there is only one line where I_C is approximately equal to both I_P and $I_{P'}$ the cornerness measure along edges is susceptible to noise.
- *Corner* - for the case where the center of the circle is on a corner, for every line at least one of I_P or $I_{P'}$ will not be in the interior region so *should* be different than I_C. Therefore, the cornerness measure will be high and is not particularly robust to noise.
- *Isolated Pixel* - for the case of an isolated pixel, for every line both I_P and $I_{P'}$ will be different than I_C so the cornerness measure will be high. An isolated pixel is likely the result of noise.

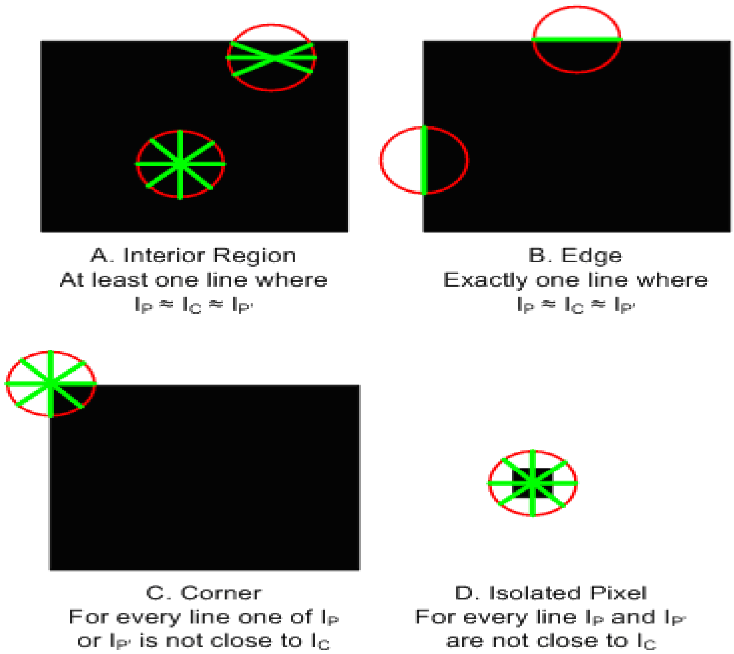

Figure 2: Different cases for the Trajkovic Operator

Based on the analysis, it is observed that Trajkovic Operator will only perform well for relatively clean images.

3. Results and Discussion

The proposed approach for personal identification using palmprint images is rigorously evaluated on palmprint image database. Figure (3, 4, 5, and 6) shows the sample images of palmprint images using several point based feature extraction methods.

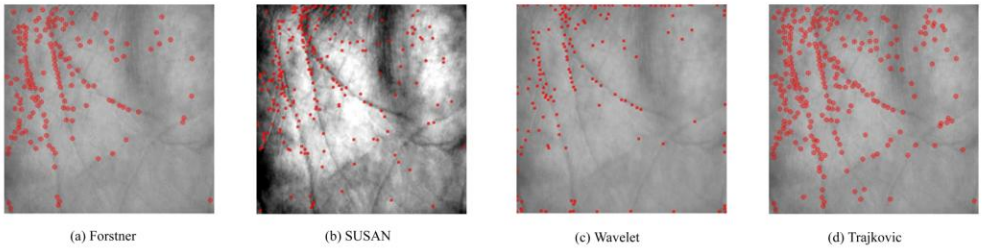

Figure 3: Point based feature extraction results for person 1 sample 1

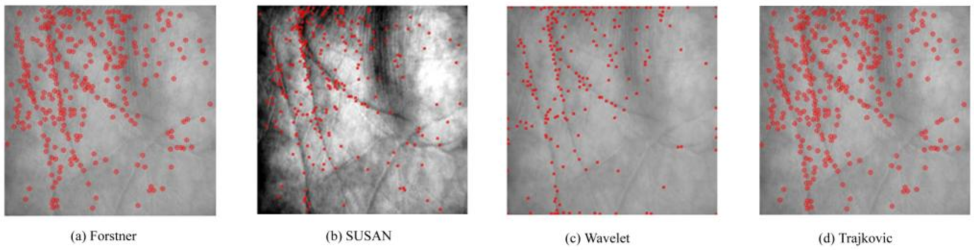

Figure 4: Point based feature extraction results for person 1 sample 2

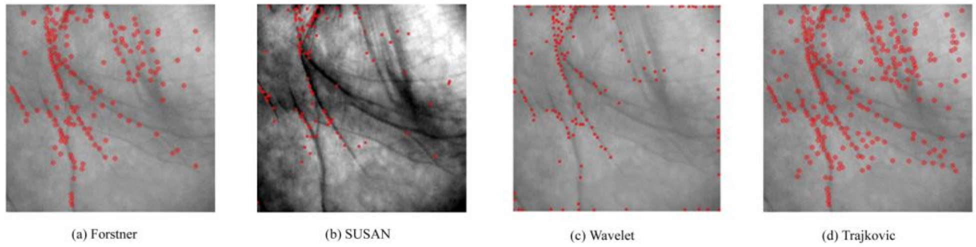

Figure 5: Point based feature extraction results for person 2 sample 1

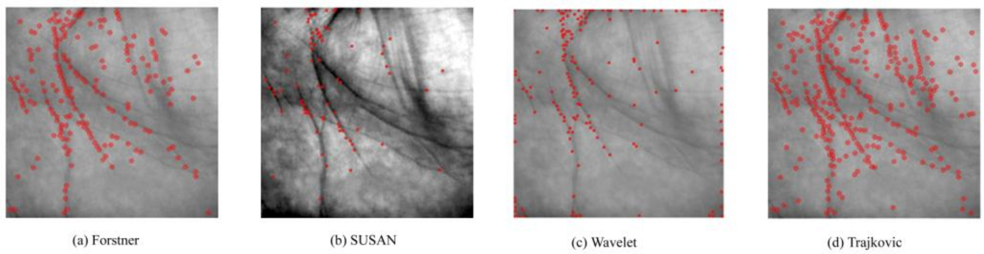

Figure 6: Point based feature extraction results for person 2 sample 2

The FAR, FRR and ROC curves for each feature extraction method is illustrated in following Figures (7, 8, 9, and 10).

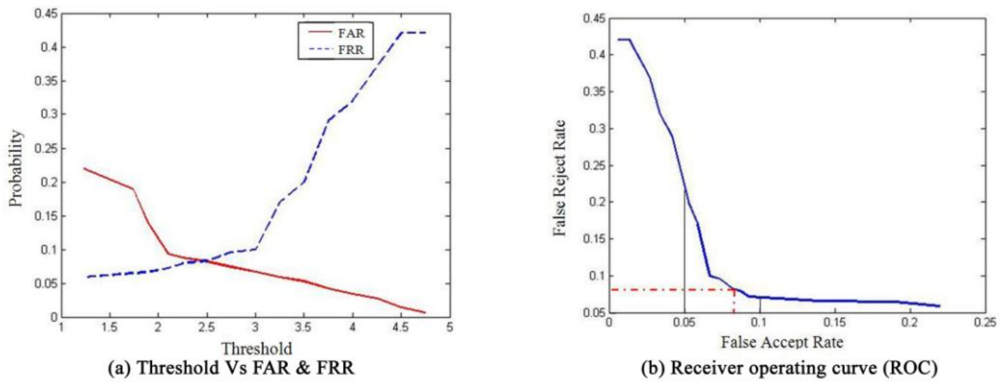

Figure 7: Accuracy plot for SUSAN operator

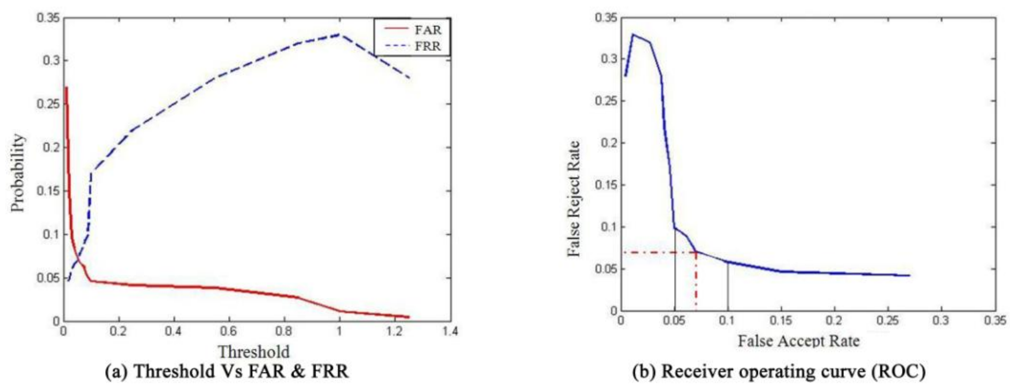

Figure 8: Accuracy plot for Wavelet operator

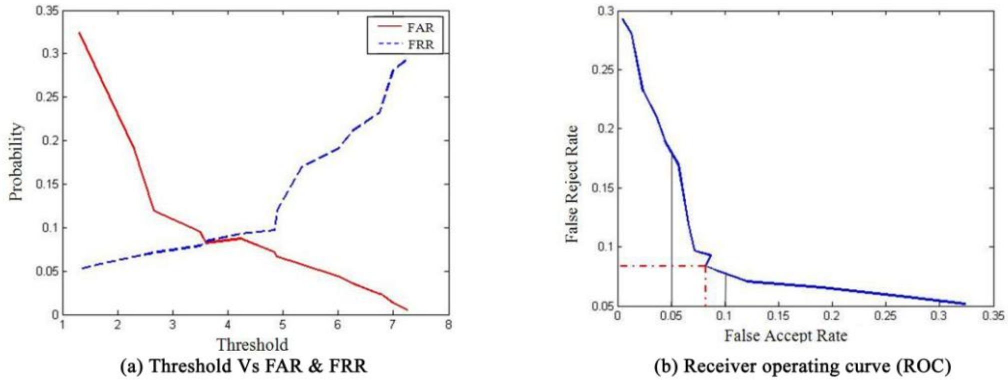

Figure 9: Accuracy plot for Trajkovic operator

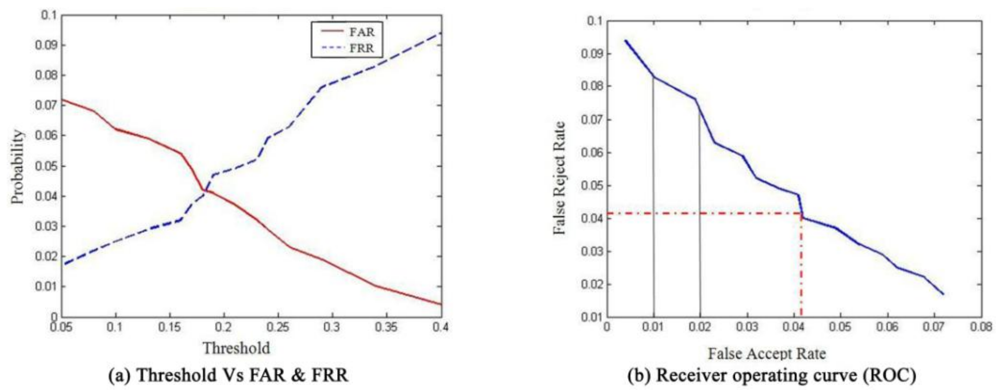

Figure10: Accuracy plot for Forstner operator

Table 1: Comparison of FAR, FRR and Accuracy of Point based methods

Method Name	FAR	FRR	Accuracy
SUSAN	0.082	0.083	91.75
WAVELET	0.0702	0.071	92.94
TRAJKOVIC	0.082	0.084	91.7
FORSTNER	**0.042**	**0.04**	**95.9**

FORSTNER perform better than other point based methods. Low FAR of 4.02% is observed.

4. Conclusion

Personal authentication using palmprint is gaining popularity because of palmprint being a feature-rich and tamper-proof biometric. Various characteristics of palmprint make it better biometric than other biometrics, i.e. Universality, Distinctiveness, Permanence, Collectability, Performance, Acceptability and Circumvention. The palmprint is feature rich biometrics with various types of features as geometry features, line features, point features, texture features and statistical features. Here, palmprint authentication using various point based methods is discussed. All the methods are analyzed with programming in MATLAB. It is very important while discussing authentication, that it is not possible to do ideal (100%) authentication. There are chances of person getting false accepted or rejected. All these factors have to be taken into consideration while talking about authentication. It is well known facts that increase in FAR leads to less security or not proper authentication because any person can be accepted as genuine. Same applies with FRR, false rejection leads to more time taken for authentication by a genuine person. There has to be a balance between the both FAR and FRR for proper authentication. Here, the main aim is to have low FAR as possible. For each type of features extracted and analyzed, best method is chosen. Out of all the various methods discussed, FORSTNER performed best with FAR of 4.02%.

References

[1] A. H. M. Al-Helali, W. A. Mahmmoud, H. A. Ali, "A Fast Personal Palmprint Authentication Based On 3D-Multi Wavelet Transformation", Transnational Journal of Science and Technology, September 2012 edition vol.2, No.8, Pages 1-10.

[2] Ajay K., Wong D. C. M., Shen H. C. and Anil K. J., "Personal Verification Using Palmprint and Hand Geometry Biometric", Proceeding of 4th International Conference on Audio- and Video-Based Biometric Person Authentication, Guildford, UK, 2003, Pages 668–678.

[3] CANNY J.F.: 'A computational approach to edge detection', IEEE Trans. Pattern Anal. Mach. Intell., Vol. 8, No. 6, 1986, Pages 112–131.

[4] Chen J., Zhang C. S. and Rong G., "Palmprint recognition using crease", Proceedings of International Conference on Image Processing 2001, Vol 3, 7-10 October 2001, Thessaloniki, Greece, Pages 234-237.

[5] Chen W. S., Chiang Y. S. and Chiu Y. H., "Biometric Verification by Fusing Hand Geometry and Palmprint", Third International Conference on Intelligent Information Hiding and Multimedia Signal Processing 2007, Vol 2, 26-28 November 2007, Kaohsiung, Taiwan, Pages 403-406.

[6] Doi, J. and Yamanaka, M., "Personal authentication using feature points on finger and palmar creases", Proceedings of 32nd Applied Imagery Pattern Recognition Workshop 2003, 15-17 Oct. 2003, Washington, DC, United States of America, Pages 282-287.

[7] Dongmei Sun, Zhengding Qiu, Qiang Li, "Palmprint Identification using Gabor Wavelet Probabilistic Neural Networks", ICSP2006 Proceedings, Vol. 4, 2006.

[8] Duta N., Anil K. J. and Kanti V. M., "Matching of palmprints", Pattern Recognition Letters, Vol 23, Issue 4, February 2002, Pages 477-485.

[9] Edward Wong Kie Yih, G. Sainarayanan, Ali Chekima,"Palmprint based biometric system: A comparative study on discrete cosine transform energy, wavelet transform energy and sobelcode methods", Biomedical Soft Computing and Human Sciences, Vol. 14, No. 1, 2009, Pages 11-19.

[10] Guang-Ming Lu, Kuan-Quan Wang, David Zhang, "Wavelet Based Independent Component Analysis for Palmprint Identification", Proceedings of the Third International Conference on Machine Learning and Cybernetics, Vol. 6, Shanghai, 26-29 August 2004, Pages 3547-3550.

[11] H B Kekre and V A Bharadi. "Texture Feature Extraction using Partitioned/Sectorized Complex Planes in Transform Domain for Iris & Palmprint Recognition", IJCA Proceedings on International Conference and workshop on Emerging Trends in Technology, ICWET(3), March 2012, Published by Foundation of Computer Science, New York, USA, Pages 18-24.

[12] Han C. C., Cheng H. L., Lin C. L. and Fan K. C., "Personal authentication using palm-print features", Pattern Recognition, Vol 36, Issue 2, February 2003, Pages 371-381.

[13] Harris and M.J. Stephens, "A combined corner and edge detector," in 4th Alvey Vision Conference, Manchester, UK, 1988, Pages 147–151.

[14] Jifeng Dai and Jie Zhou, "Multifeature- Based High Resolution Palmprint Recognition," IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 33, No. 5, May 2011, Pages 945-957.

[15] Jyoti Malik, Ratna Dahiya & G Sainarayanan, "Fast Complex Gabor Wavelet Based Palmprint Authentication", International Journal of Image Processing (IJIP), Vol 5, Issue 3, Sep 2011, Pages 283-297.

[16] Kong W. K. and Zhang D., "Palmprint texture analysis based on low-resolution images for personal authentication", Proceedings of 16th International Conference on Pattern Recognition 2002, Vol 3, 11-15 August 2002, Quebec city, QC, Canada, Pages 807-810.

[17] Kovesi P. "Image features from Phase Congruency", Videre J. Comput. Vis. Res., Vol. 1, No. 3, Pages 1–26, 1999.

[18] Lei Zhang and David Zhang, "Characterization of Palmprints by Wavelet Signatures via Directional Context Modeling" IEEE Transactions on Systems, Man, And Cybernetics—Part B: Cybernetics, Vol. 34, No. 3, June 2004, Pages 1335-1347.

[19] Li W. X., Zhang D. and Xu Z. Q., "Image alignment based on invariant features for palmprint identification", Signal Processing: Image Communication, Vol 18, Issue 5, May 2003, Pages 373-379.

[20] Li W., Zhang D., and Xu Z., "Palmprint Identification by Fourier Transform", International Journal of Pattern Recognition and Artificial Intelligence 2002, Vol 16, No. 4, 2002, Pages 417-432.

[21] Li, W. and Zhang, D. and Zhang, L. and Lu, G. and Yan, J., "3-D Palmprint Recognition With Joint Line and Orientation Features", IEEE Trans. Systems, Man, and Cybernetics, Part C, 41(2), 2011, Pages 274 -279.

[22] Lu G. M., Wang K. Q. and Zhang, D., "Wavelet based independent component analysis for palmprint identification", Proceedings of 2004 International Conference on Machine Learning and Cybernetics, Vol 6, 26-29 August 2004, Shanghai, China, Pages 3547-3550.

[23] Rafael D. M., Travieso, C. M., Alonso, J. B. and Ferrer, M. A., "Biometric system based in the feature of hand palm", 38th Annual 2004 International Carnahan Conference on Security Technology, 11-14 October 2004, Albuquerque, New Mexico, United States of America, Pages 136-139.

[24] Struc V and N. Pavesic, "Phase Congruency features for palmprint verification", IET Signal Processing, Vol. 3, Issue 4, 2008, Pages 258-268.

[25] Tantachun, S., Pintavirooj, C., Lertprasart P. and Bunluechokchai S., "Biometrics with Eigen-Hand", 1st IEEE Conference on Industrial Electronics and Applications 2006, 23 – 26 May 2006, Singapore, Pages 1-4.

[26] Tao J. W., Jiang W., Gao Z., Chen S. and Wang C., "Palmprint Recognition Based on 2-Dimension PCA", First International Conference on Innovative Computing, Information and Control 2006, ICICIC '06, Vol 1, 30-01 August 2006, Beijing, China, Pages 326-330.

[27] Wang M. and Ruan Q. Q., "Palmprint Recognition Based on Two-Dimensional Methods", The 8th International Conference on Signal Processing, Vol 4, 16-20 November 2006, Guilin, China.

[28] Wei X. Y., Xu D. and Ngo C. W., "Multi-biometrics based on palmprint and hand geometry", Proceeding of the Fourth Annual ACIS International Conference on Computer and Information Science 2005, Jeju Island, South Korea, Pages 495–500.

[29] Wong K. Y. E., G. Sainarayanan and Ali Chekima, "Palmprint Identification Using SobelCode" Malaysia-Japan International Symposium on Advanced Technology 2007, 12-15 November 2007, Kuala Lumpur, Malaysia.

[30] Wong, M., Zhang, D., Kong, W. K. and Lu, G., "Real-time palmprint acquisition system design", IEE Proceedings - Vision, Image and Signal Processing, Vol 152, Issue 5, 7 October 2005, Pages 527-534.

[31] Wu X. Q., Wang K. Q. and Zhang D., "Wavelet based palm print recognition", Proceedings of International Conference on Machine Learning and Cybernetics 2002, Vol 3, 4-5 November 2002, Beijing, China, Pages 1253-1257.

[32] Wu X. Q., Wang K. Q. and Zhang D., "Wavelet Energy Feature Extraction and Matching for Palmprint Recognition", Journal of Computer Science and Technology, Vol 20, No. 3, May 2005, Pages 411-418.

[33] Wu X. Q., Zhang D., Wang K. Q. and Huang B., "Palmprint Classification Using Principal Line", Pattern Recognition, Vol 37, Issue 10, October 2004, Pages 1987-1998.

[34] Xiangqian Wu, Kuan-Quan Wang, David Zhang "Palmprint Recognition Using Fisher's Linear Discriminant" Proceedings of the Second International Conference on Machine Learning and Cybernatics, Vol. 5, 2-5 November 2003, Pages 3150-3154.

[35] Xiao-Yuan Jing and David Zhang, "A Face and Palmprint Recognition Approach Based on Discriminant DCT Feature Extraction", IEEE Transactions On Systems, Man, And Cybernetics—Part B: Cybernetics, Vol. 34, issue 6, June 2004, Pages 2405-2415.