DEVELOPMENT OF FINGER VEIN IDENTIFICATION SYSTEM USING FEATURE COMBINATION AND DIMENSIONALITY REDUCTION

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Master of Science

UNIVERSITI MALAYSIA PAHANG

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Dengan peningkatan globalisasi dan taraf hidup manusia, sifat biometrik vena jari menjadi tumpuan utama dalam sistem pengiktirafan dan sistem sekuriti. Vena jari adalah sejenis biometrik yang sangat berkesan kerana ia sukar untuk dicuri atau diduplikasi kerana ia bersembunyi di bawah kulit jari. Kualiti dan kontras imej merupakan masalah utama yang dihadapi oleh penyelidik-penyelidik dalam sistem pengenalan vena jari. Ia boleh berlaku disebabkan postur yang salah, keamatan cahaya dan putaran imej semasa sesi tangkapan gambar. Kerja-kerja terdahulu telah menyatakan bahawa ciri-ciri wavelet dapat mengatasi masalah putaran gambar manakala ciri-ciri berasaskan binari tempatan teguh terhadap ketepuan imej dan teduhan yang tidak teratur. Walau bagaimanapun, gabungan kedua-dua ciri yang berbeza ini masih baru dalam sistem pengenalan vena jari. Selain itu, teknik pengurangan dimensi seperti *Principal Component Analysis* (PCA) dan *Linear Discriminant Analysis* (LDA) sering digunakan dalam sistem pengenalan vena jari sejak kebelakangan ini. Secara amnya, PCA digunakan untuk mengeluarkan bunyi imej yang berada di dimensi yang dibuang. Walau bagaimanapun, pengurangan ciri di peringkat awal dengan menggunakan PCA boleh menghilangkan ciri-ciri penting kerana PCA mungkin menyimpulkan bahawa maklumat untuk eigenvalue yang bersesuaian adalah bunyi bising. Oleh itu, kajian ini mencadangkan pengenalan vein jari menggunakan ciri-ciri gabungan *Discrete Wavelet Transform* (DWT) dan *Local Binary Pattern* (LBP). Ciri-ciri gabungan ini kemudian menjalani pengurangan dimensi dengan menggunakan PCA dan LDA. Imej vena jari terlebih dahulu menjalani pra-pemprosesan imej bagi meningkatkan kualiti imej, diikuti dengan pengeluaran kawasan kepentingan (ROI) urat jari; pada masa yang sama mengeluarkan bunyi imej. Imej vena jari yang telah diproseskan akan menjalani pengekstrakan ciri dengan menggunakan DWT dan LBP ;dan ciri-ciri vena jari yang dihasilkan adalah dalam bentuk vektor. Ciri-ciri itu kemudian digabungkan. Proses sistem ini diteruskan dengan menggunakan PCA atau LDA pada ciri gabungan tersebut. *Linear Support Vector Machine* (SVM) dan *Fine K-Nearest Neighbours* (FKNN) digunakan sebagai kaedah klasifikasi dalam kajian ini. Pada masa yang sama, sistem pengenalan vein jari konvensional juga direka dengan *Repeated Line Tracking* (RLT) dan *Maximum Curvature* (MAXC) sebagai kaedah pengekstrakan ciri ; diikuti dengan *Speeded up Robust Features* (SURF) sebagai kaedah klasifikasi. Prestasi sistem yang dicadangkan ini dibandingkan dengan sistem pengenalan vena jari yang konvensional dengan menggunakan pangkalan data yang sama iaitu SDMULA-HMT. Sepanjang eksperimen, gabungan ciri DWT dan LBP terbukti berfungsi dengan lebih baik daripada sistem pengenalan urat jari yang melibatkan hanya satu jenis ciri dengan peningkatan purata sebanyak 6.91%. Pada peringkat awal, sistem yang dicadangkan mencapai kadar pengenalan 80.16%, yang sedikit lebih rendah daripada sistem konvensional. Walau bagaimanapun, apabila sistem yang dicadangkan dan sistem konvensional terlibat dengan pengurangan dimensi seperti PCA dan LDA, kadar pengenalan meningkat secara dramatik dalam sistem yang dicadangkan sementara hanya peningkatan kecil pada sistem pengenalan vena konvensional jari. Sistem yang dicadangkan mencapai kadar pengenalan tertinggi pada 100% apabila ciri tersebut dilakukan menggunakan LDA pada dimensi ciri 30.

ABSTRACT

With the increase in globalization and living standard, finger vein biometric trait becomes a popular focus in the human recognition and security system. Finger vein is high security as it is hard to be stolen or duplicate since it hides underneath the finger skin. Image quality and contrast is the main problem that was faced by researcher in the finger vein identification system. It may cause by the wrong posture, light intensity and image rotation during the image captured session. Previous works had stated that the wavelet-based features are invariant to image rotation while local binary based features robust against high saturation and irregular shading. However, the feature combination of these two different features type has not been studied yet in finger vein identification system. Besides that, the dimensionality reduction technique such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) was frequently involved in finger vein recognition system in this recent year. Generally, PCA was used to remove the noise residing in the discarded dimension. However, the features reduction in earlier stage using PCA may remove the important features as PCA might remove the local information where it concludes that the information for the corresponding eigenvalue is noise. Therefore, this research proposed to develop a finger vein identification using combination features of Discrete Wavelet Transform (DWT) and Local Binary Pattern (LBP). The combined features were then undergoing dimensionality reduction using PCA and LDA. The finger vein image firstly undergoes image pre-processing to enhance the image quality, followed by region of interest (ROI) extraction and noise removal using median filtering. The pre-processed finger vein images will go through feature extraction using DWT and LBP to get the features in vectors form and then combined. The process was continued by applying PCA or LDA on the combination features. Linear Support Vector Machine (SVM) and Fine K-Nearest Neighbours (FKNN) were used for classification in this research. At the same time, the conventional finger vein identification system was designed with Repeated Line Tracking (RLT) and Maximum Curvature (MAXC) as feature extraction methods followed by Speeded-up Robust Features (SURF) as the classification method. The performance of the proposed system was compared with the conventional finger vein identification system using same database which is known as SDMULA-HMT. Throughout the experiments, the feature combination of DWT and LBP was proved to perform better than the finger vein identification system that involved only single type of feature by average of 6.91% improvement. At the early stage, the proposed system achieved 80.16% identification rate, which is a bit lower than the conventional system. However, when the proposed system and the conventional system are applied with dimensionality reduction using PCA and LDA, the identification rate increased dramatically in proposed system while there was only small improvement on the conventional finger vein identification system. The proposed system achieved the highest identification rate at 100% when the feature is performed using LDA at feature dimension of 30.

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Alpha	Direction of the edges
$Alpha_i$	Valley depth
B	Kernel of the Gaussian filter
C_n	Covariance of single class
$\|Gradient\|$	Gradient magnitude
K_{GX}	Gradient in x- direction
K_{GY}	Gradient in y- direction
N_{avg}	Average number of pixels
N_c	Centre pixels
$N_{CR\text{-}XP}$	Number of pixels in X direction of contextual region
$N_{CR\text{-}YP}$	Number of pixels in Y direction of contextual region
N_{grey}	Number of grey level in contextual region
N_P	Neighbour pixels
Sigma	Standard deviation
s(x)	Threshold for neighbourhoods pixels
S(t)	Covariance matrix

LIST OF ABBREVIATIONS

AHE	Adaptive Histogram Equalization
ANFIS	Adaptive Neuro-fuzzy
ANN	Artificial Neural Network
CLAHE	Contrast-limited Adaptive Histogram Equalization
DLPP	Discriminant locality preserving projection
DWPT	Discrete Wavelet Packet Transform
DWT	Discrete Wavelet Transform
ED	Euclidean distance
HD	Hamming distance
HH	Diagonal details
HL	Horizontal details
KNN	K Nearest Neighbour
LBP	Local Binary Pattern
LDA	Linear discriminant analysis
LDC	Local Directional Code
LED CCD	Near-infrared light
LH	Vertical details
LL	Approximate image
LLBP	Local Line Binary Pattern
LOOCV	Leave One Out Cross Validation
LSVM	Linear Support Vector Machine
MAXC	Maximum Curvature
NIR	Near-infrared
ONPP	Orthogonal Neighbourhood Preserving Projections
PBBM	Personalized best bit maps
PC	Principal component
PCA	Principal component analysis
RLT	Repeated Line Tracking
ROI	Region of Interest
SIFT	Scale- Invariant Feature Transform
SURF	Speeded Up Robust Features
SVM	Support vector machine

REFERENCES

Awad, M., & Khanna, R. (2015). Support Vector Machines for Classification. In *Efficient Learning Machines: Theories, Concepts, and Applications for Engineers and System Designers* (pp. 39–66). Berkeley, CA: Apress. https://doi.org/10.1007/978-1-4302-5990-9_3

Chihaoui, T., Jlassi, H., Kachouri, R., Hamrouni, K., & Akil, M. (2016). Personal verification system based on retina and SURF descriptors. *13th International Multi-Conference on Systems, Signals and Devices, SSD 2016*, 280–286. https://doi.org/10.1109/SSD.2016.7473709

Chunyi, L., Mingzhong, L., & Xiao, S. (2012). A Finger Vein Recognition Algorithm Based on Gradient Correlation. *AASRI Procedia*, *1*, 40–45. https://doi.org/10.1016/j.aasri.2012.06.008

Elnasir, S., Shamsuddin, S. M., Akbar, S., Ahmad, A., & Hayat, M. (2014). Identification of Fingerprint Using Discrete Wavelet Transform in Conjunction with Support Vector Machine. *International Journal of Advances in Soft Computing and Its Applications*, *6*(5), 189–199.

Gupta, P., & Gupta, P. (2015). An accurate finger vein based verification system. *Digital Signal Processing*, *38*, 43–52. https://doi.org/10.1016/j.dsp.2014.12.003

Hu, L. Y., Huang, M. W., Ke, S. W., & Tsai, C. F. (2016). The distance function effect on k-nearest neighbor classification for medical datasets. *SpringerPlus*, *5*(1). https://doi.org/10.1186/s40064-016-2941-7

Jiang, X., Mandal, B., & Kot, A. (2008). Eigenfeature regularization and extraction in face recognition. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *30*(3), 383–394.

Johnson, J. M., & Yadav, A. (2018). Fault detection and classification technique for HVDC transmission lines using KNN. *Information and Communication Technology for Sustainable Development*, (August), 245–253. https://doi.org/10.1007/978-981-10-3920-1_25

Kaur, M., Babbar, G., & Landran, C. E. C. (2015). Finger Vein Detection using Repeated Line Tracking , Even Gabor and Multilinear Discriminant Analysis (MDA), *6*(4), 3280–3284.

Khellat-kihel, S., Cardoso, N., Monteiro, J., & Benyettou, M. (2014). Finger Vein Recognition Using Gabor Filter and Support Vector Machine. *Image Processing, Applications and Systems Conference (IPAS), 2014 First International*, 1–6. https://doi.org/10.1109/IPAS.2014.7043263

Kumar, A., & Yingbo Zhou. (2012). Human Identification Using Finger Images. *IEEE Transactions on Image Processing*, *21*(4), 2228–2244. https://doi.org/10.1109/TIP.2011.2171697

Lee, E. C., Jung, H., & Kim, D. (2011). New Finger Biometric Method Using Near Infrared Imaging. *Sensors*, *11*(3), 2319–2333. https://doi.org/10.3390/s110302319

Liu, T., Xie, J. B., Yan, W., Li, P. Q., & Lu, H. Z. (2013). An algorithm for finger-vein segmentation based on modified repeated line tracking. *The Imaging Science Journal*, *61*(6), 491–502. https://doi.org/10.1179/1743131X12Y.0000000013

Liu, Z., Yin, Y., Wang, H., Song, S., & Li, Q. (2010). Finger vein recognition with manifold learning. *Journal of Network and Computer Applications*, *33*(3), 275–282. https://doi.org/10.1016/j.jnca.2009.12.006

Lu, Y., Yoon, S., & Park, D. S. (2013). Finger Vein Recognition based on Matching Score-Level Fusion of Gabor Features, *38*(2), 178–182.

Manthalkar, R., Biswas, P. K., & Chatterji, B. N. (2003). Rotation and scale invariant texture features using discrete wavelet packet transform. *Pattern Recognition Letters*, *24*(14), 2455–2462. https://doi.org/10.1016/S0167-8655(03)00090-4

Meng, X., Yang, G., Yin, Y., & Xiao, R. (2012). Finger Vein Recognition Based on Local Directional Code. *Sensors*, *12*(11), 14937–14952. https://doi.org/10.3390/s121114937

Miura, N., Nagasaka, A., & Miyatake, T. (2004). Feature extraction of finger-vein patterns based on repeated line tracking and its application to personal identification. *Machine Vision and Applications*, *15*(4), 194–203.

Nguyen, D. T., Park, Y. H., Shin, K. Y., Kwon, S. Y., Lee, H. C., & Park, K. R. (2013). Fake finger-vein image detection based on Fourier and wavelet transforms. *Digital Signal Processing*, *23*(5), 1401–1413. https://doi.org/10.1016/j.dsp.2013.04.001

Park, K. R. (2011). Finger vein recognition by combining global and local features based on SVM. *Computing and Informatics*, *30*(2), 295–309.

Rosdi, B. A., Shing, C. W., & Suandi, S. A. (2011). Finger vein recognition using local line binary pattern. *Sensors, 11*(12), 11357–11371.

Sato, H. (2009). Finger Vein Authentication, (January), 13–14.

Seong, T. W., Ibrahim, M. Z., Arshad, N. W. B., & Mulvaney, D. J. (2018). A Comparison of Model Validation Techniques for Audio-Visual Speech Recognition. In K. J. Kim, H. Kim, & N. Baek (Eds.), *IT Convergence and Security 2017* (pp. 112–119). Singapore: Springer Singapore.

Shareef, A. Q., George, L. E., & Fadel, R. E. (2015). Finger Vein Recognition Using Haar Wavelet Transform, *4*(3), 1–7.

Shrikhande, S. P. (2015). Finger Vein Recognition Using Discrete Wavelet Packet Transform Based Features, 1646–1651.

Shrikhande, S. P. (2016). Finger Vein Recognition using Rotated Wavelet Filters, *149*(7), 28–33.

Singh, R. P., & Dixit, M. (2015). Histogram Equalization: A Strong Technique for Image Enhancement. *International Journal of Signal Processing Image Processing and Pattern Recognition*, *8*(8), 345–352. https://doi.org/10.14257/ijsip.2015.8.8.35

Song, W., Kim, T., Kim, H. C., Choi, J. H., Kong, H.-J., & Lee, S.-R. (2011). A finger-vein verification system using mean curvature. *Pattern Recognition Letters*, *32*(11), 1541–1547. https://doi.org/10.1016/j.patrec.2011.04.021

Syazana-Itqan, K., Syafeeza, A. R., Saad, N. M., Hamid, N. A., & Saad, W. H. B. M. (2016). A Review of Finger-Vein Biometrics Identification Approaches. *Indian Journal of Science and Technology*, *9*(32).

Tagkalakis, F., & Fotopoulos, V. (2015). A low cost finger vein authentication system, using maximum curvature points. *Applied Electronics (AE), 2015 International Conference On*, 249–252.

Tallam Temgire, S. and Zirange, R., R. (2014). Finger Vein Recognition System Using Image Processing. *Proceedings of 4th IRF International Conference, Pune,* (5), 65–68. https://doi.org/16th March-2014, Ting, E. W., Ibrahim, M. Z., & Mulvaney, D. J. (2018). Investigation of Dimensionality Reduction in a Finger Vein Verification System. In K. J. Kim, H. Kim, & N. Baek (Eds.), *IT Convergence and Security 2017* (pp. 194–201). Singapore: Springer Singapore.

Ton, B. T., & Veldhuis, R. N. J. (2013). A high quality finger vascular pattern dataset collected using a custom designed capturing device. *Proceedings - 2013 International Conference on Biometrics, ICB 2013*. https://doi.org/10.1109/ICB.2013.6612966

Turka, K., & Kaur, G. (2014). Review On : Finger Vein Detection Using Repeated Line , Even Gabor and Median Filter. *International Journal of Computer Science and Information Technologies(IJCSIT)*, *5*(3), 3695–3698.

Wang, S., & Liu, P. (2015). A new feature extraction method based on the information fusion of entropy matrix and covariance matrix and its application in face recognition. *Entropy*, *17*(7), 4664–4683. https://doi.org/10.3390/e17074664

Wu, J.-D., & Liu, C.-T. (2011). Finger-vein pattern identification using SVM and neural network technique. *Expert Systems with Applications*, *38*(11), 14284–14289. https://doi.org/10.1016/j.eswa.2011.05.086

Yanagawa, T., Aoki, S., & Ohyama, T. (2007). Human finger vein images are diverse and its patterns are useful for personal identification. *MHF Prepr. Ser*, *12*, 1–7.

Yang, G., Xi, X., & Yin, Y. (2012a). Finger vein recognition based on (2D) 2 PCA and metric learning. *Journal of Biomedicine and Biotechnology*, *2012*. https://doi.org/10.1155/2012/324249

Yang, G., Xi, X., & Yin, Y. (2012b). Finger Vein Recognition Based on a Personalized Best Bit Map. *Sensors*, *12*(12), 1738–1757. https://doi.org/10.3390/s120201738

Yang, J., & Zhang, X. (2012). Feature-level fusion of fingerprint and finger-vein for personal identification. *Pattern Recognition Letters*, *33*(5), 623–628.

Yang, L., Yang, G., Yin, Y., & Zhou, L. (2014). A survey of finger vein recognition. In *Chinese Conference on Biometric Recognition* (pp. 234–243). Springer.

Yang, W., Huang, X., Zhou, F., & Liao, Q. (2014). Comparative competitive coding for personal identification by using finger vein and finger dorsal texture fusion. *Information Sciences*, *268*, 20–32.

Yin, Y., Liu, L., & Sun, X. (2011). SDUMLA-HMT: a multimodal biometric database. In *Chinese Conference on Biometric Recognition* (pp. 260–268). Springer.

Zharov, V. P., Ferguson, S., Eidt, J. F., Howard, P. C., Fink, L. M., & Waner, M. (2004). Infrared imaging of subcutaneous veins. *Lasers in Surgery and Medicine, 34*(1), 56–61. https://doi.org/10.1002/lsm.10248

Zhu, L. Q. (2011). Finger knuckle print recognition based on SURF algorithm. *Proceedings - 2011 8th International Conference on Fuzzy Systems and Knowledge Discovery, FSKD 2011*, *3*, 1879–1883. https://doi.org/10.1109/FSKD.2011.6019781