Journal of Quality Measurement and Analysis *JQMA* 9(1) 2013, 33-46
Jurnal Pengukuran Kualiti dan Analisis

KEBERKESANAN PENGAMBANGAN ENTROPI BERSILANGAN DAN ENTROPI TSALLIS UNTUK SISTEM PENGECAMAN BALISTIK FORENSIK AUTOMATIK

(Effectiveness of Cross-Entropy and Tsallis Entropy Thresholding for Automatic Forensic Ballistics Identification System)

ZUN LIANG CHUAN, ABDUL AZIZ JEMAIN, CHOONG-YEUN LIONG &
NOR AZURA MD GHANI

ABSTRAK

Kelongsong peluru yang dijumpai di tempat kejadian adalah penunjuk yang penting dalam penyiasatan kes jenayah bersenjata api. Pihak penguat kuasa undang-undang berupaya untuk mengenal pasti jenis dan model senjata api yang digunakan oleh penjenayah menerusi kelongsong peluru yang ditemui di tempat kejadian jenayah. Pemetakan rantau tumpuan berdasarkan kedudukan kesan pin peletup pada tapak kelongsong adalah langkah yang kritikal dalam sistem pengecaman balistik automatik. Walaupun beberapa kaedah pengesanan kedudukan kesan pin peletup telah disarankan dalam pelbagai kajian lepas; namun begitu, kaedah yang disarankan itu amat kompleks dan memerlukan masa pelaksanaan yang panjang. Justeru, kajian ini mengemukakan suatu sistem pengecaman balistik forensik automatik yang terampil dan pantas. Penganggar pengesanan kedudukan kesan pin peletup yang digunakan dalam sistem didapati adalah terampil dan teguh terhadap hingar. Sistem yang disarankan terbentuk daripada gabungan operasi penuras penajaman Laplacean, operasi penormalan histogram, dua kaedah pengambangan berasaskan entropi, dan penganggar kuasa dua terkecil penyuaian bulatan tak berpemberat. Dua kaedah pengambangan berasaskan entropi yang terkenal yang mengoptimum dan meminimum kriterium entropi tertentu diterokai dalam makalah ini. Sebanyak 747 imej kesan pin peletup yang dikumpulkan daripada lima pucuk pistol model Parabellum Vektor SP1 9mm digunakan untuk menguji keterampilan sistem yang disarankan. Kadar kejituan pengecaman senjata api bagi sistem terbaik yang dirumuskan dalam makalah ini adalah 95.4% dengan purata masa pelaksanaan 0.37 saat per imej.

Kata kunci: balistik forensik; kriminalistik; pengecaman spesimen balistik; pengambangan berasaskan entropi

ABSTRACT

Firearm cartridge cases found in the crime scenes are important clues in investigation of crimes that involved firearms. Law enforcement agencies are able to identify the type and model of firearms used by criminal based on the cartridge cases found in the crime scenes. Segmenting the region of interest based on the position of key impressions formed on the cartridge cases is a critical stage in an automatic ballistic identification system. Although several methods have been proposed to detect the position of key impressions in various previous studies; however, the proposed methods are very complex and time consuming. Hence, the aim of this study is to propose an automatic ballistic identification system that is efficient in terms of accuracy and speed. The estimator used to detect the firing pin impression in the proposed system is found to be efficient and robust to noise. The proposed systems involve combination of Laplacian sharpening filter, histogram normalisation, two types of entropy-based thresholding, and an unweighted least square approach for fitting of circular estimator. Two popular entropy-based thresholding methods that optimise and minimise a particular entropy criterion have been investigated in this study. A total of 747 firing pin impression images collected from five pistols of model Vektor Parabellum SP1 9mm were used to test the proposed systems. The firearm identification accuracy rate for the best proposed system is 95.4% with an average execution time of 0.37 seconds per image.

Keywords: forensic ballistics; criminalistics; ballistics specimen identification; entropy-based thresholding

Rujukan

Albuquerque M.P.D., Esquef I.A. & Mello A.R.G. 2004. Image thresholding using Tsallis entropy. *Pattern Recognition Letters* **25**(9): 1059-1065.

Brink A.D. & Pendock N.E. 1996. Minimum cross-entropy threshold selection. *Pattern Recognition* **29**(1): 179-188.

Canny J. 1986. A computational approach to edge detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **PAMI-8**(6): 679-698.

Fan S., Yang S., He P. & Nie H. 2011. Infrared electric image thresholding using two-dimensional fuzzy Renyi entropy. *Energy Procedia* **12**: 411-419.

Fisher R.A. 1936. The use of multiple measurements in taxonomic problems. *Annals of Eugenics* **7**: 179-188.

Geradts Z.J., Bijhold J., Hermsen R. & Murtagh F. 2001. Image matching algorithms for breech face marks and firing pins in a database of spent cartridge cases of firearms. *Forensic Science International* **119**(1): 97-106.

Ghani N.A.M. 2010. Analisis spesimen balistik forensik untuk pengecaman senjata api. Tesis Dr. Fal., Pusat Pengajian Sains Matematik, Universiti Kebangsaan Malaysia.

Ghani N.A.M., Liong C.-Y. & Jemain A.A. 2010. Analysis of geometric moments as features for firearm identification. *Forensic Science International* **198**(1-3): 143-149.

Heard B.J. 2008. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. Edisi ke-2. Chichester: John Wiley & Sons.

Jones B.C. & Guerci J.R. 1997. Intelligent image capture of cartridge cases for firearms examiners. Proceedings of the SPIE 2942 on Investigative Image Processing, hlm: 94-104.

Kamaruddin S.B.A., Ghani N.A.M., Liong C.-Y. & Jemain A.A. 2011. Firearm recognition based on whole firing pin impression image via backpropagation neural network. Proceedings of the IEEE International Conference on Pattern Analysis and Intelligent Robotics, hlm. 177-182.

Kinder J.D. & Bonfanti M. 1999. Automated comparison of bullet striations based on 3D topography. *Forensic Science International* **101**(2): 85-93.

Li D.G. 2003. Image processing for the positive identification of forensic ballistics specimens. Proceedings of the 6th International Conference on Information Fusion, hlm. 1494-1498.

Leng J. & Huang Z. 2012. On analysis of circle moments and texture features for cartridge images recognition. *Expert Systems with Applications* **39**(2): 2092-2101.

Lin Q. & Ou C. 2012. Tsallis entropy and the long-range correlation in image thresholding. *Signal Processing* **92**(12): 2931-2939.

Marr D. & Hildreth E. 1980. Theory of edge detection. *Proceedings of Royal Society of London Series B, Biological Sciences* **207**(1167): 187-217.

Moura L. & Kitney R. 1991. A direct method for least-squares circle fitting. *Computer Physics Communications* **64**(1): 57-63.

Nichols R.G. 1997. Firearm and toolmark identification criteria: A review of the literature. *Journal of Forensic Science* **42**(30): 466-474.

Nie F., Gao C., Guo Y. & Gan, M. 2011. Two-dimensional minimum local cross-entropy thresholding based on co-occurrence matrix. *Computers and Electrical Engineering* **37**: 757-767.

Peckinpaugh S.H. & Holyer R.J. 1994. Circle detection for extracting eddy size and position from satellite imagery of the ocean. *IEEE Transactions on Geoscience and Remote Sensing* **32**(2): 267-273.

Sakarya U., Topçu O., Leloğlu U.M., Soysal M. & Tunalı E. 2012. Automated region segmentation on cartridge case base. *Forensic Science International* **222**(1-3): 277-287.

Smith C.L. 1997. Fireball: A forensic ballistics imaging system. Proceedings of the IEEE International 31st Annual 1997 Carnahan Conference on Security Technology, hlm. 64-70.

Sobel I. 1978. Neighbourhood coding of binary images for fast contour following and general array binary processing. *Computer Graphics and Image Processing* **8**(1): 127-135.

Tang Y., Mu W., Zhang Y. & Zhang X. 2011. A fast recursive algorithm based on fuzzy 2-partition entropy approach for threshold selection. *Neurocomputing* **74**(17): 3072-3078.

Wu W.-Y. & Yu W.-B. 2009. Subpixel detection of circular objects using geometric property. World Academy of Science, Engineering and Technology **56**: 236-240.

Xin L.-P., Zhou J. & Rong G. 2000. A cartridge identification system for firearm authentication. Proceedings of the 5th International Conference on Signal Processing, hlm. 1405-1408.

Zhou J., Xin L.-P., Gao D.-S., Zhang C.-S. & Zhang D. 2001. Automated cartridge identification for firearm authentication. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, hlm. 749-754.

Pusat Pengajian Sains Matematik
Fakulti Sains dan Teknologi
Universiti Kebangsaan Malaysia
43600 UKM Bangi
Selangor DE, MALAYSIA
*Mel-e: chuan_zl@yahoo.com.my, azizj@ukm.my, lg@ukm.my**

Pusat Pengajian Statistik dan Sains Pemutusan
Fakulti Sains Komputer dan Matematik
Universiti Teknologi MARA
40450 Shah Alam
Selangor DE, MALAYSIA
Mel-e: azura@tmsk.uitm.edu.my

**Penulis untuk dihubungi*