

## **KEBERKESANAN PENGAMBANGAN ENTROPI BERSILANGAN DAN ENTROPI TSALLIS UNTUK SISTEM PENGECEMAN BALISTIK FORENSIK AUTOMATIK**

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

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### *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 mengoptimimum dan meminimum kriteria 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

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