B169 Proposed Congruent Match Cross-Section (CMX) Method for Ballistics Identification of Firing Pin Impressions

Junfeng J. Song, MS, NIST, 100 Bureau Drive, MS 8212, Gaithersburg, MD 20899; Mingsi Tong, PhD, NIST, 100 Bureau Drive, MS 8212, Gaithersburg, MD 20899; Hao M. Zhang, PhD, NIST, 100 Bureau Drive, MS 8212, Gaithersburg, MD 20899; Wei Chu, NIST, 100 Bureau Drive, MS 8212, Gaithersburg, MD 20899; and Robert M. Thompson, BS*, NIST, Special Programs Office-Forensic Sciences, 100 Bureau Drive, MS 8102, Gaithersburg, MD 20899*

After attending this presentation, attendees will understand how to use a new method called the CMX Method developed at the National Institute of Standards and Technology (NIST) for ballistics identification of firing pin impressions.

This presentation will impact the forensic science community by providing a new method — the CMX Method — for fast and accurate ballistics identification of firing pin images.

Reporting an error rate for forensic evidence identification is a fundamental challenge in forensic science.[1] It is a national priority to establish a scientific procedure for quantitative error rate reports to support firearm and impression identifications in court proceedings.[2] The Congruent Matching Cells (CMC) method was recently invented at the NIST for accurate image-related forensic evidence identification and error rate estimation.[3,4] The CMC method is based on the principle of discretization — it divides the entire image into small correlation regions and uses multiple identification parameters for accurate forensic evidence identification. This enables the estimation of error rates and the Likelihood Ratio (LR) based on statistical analysis of the total number of correlation cells, the number of qualified CMC cell pairs, and the statistical distribution of the four identification parameters.

Validation tests of the CMC method for correlation of breechface impressions have recently been completed using 40 cartridge cases fired with consecutively manufactured pistol slides.[5] These tests include 717 Known-Non-Matching (KNM) and 63 Known-Matching (KM) image correlations. The results do not produce any false positive or false negative identifications and hence provide strong initial support for the effectiveness of the CMC method for correlation of the breechface impressions. An approach for calculating error rates has also been developed using the CMC method.[4]

Firing pin impressions on cartridge cases are an important part of firearms evidence identifications; however, in comparison to the CMC correlation for breechface impressions with millimeter-sized correlation areas, there is only a limited correlation area (sub-millimeter) on the firing pin impressions. Furthermore, the concave shape of firing pin impressions makes it difficult for automatic correlations. A new method and related algorithm, CMX, are proposed for correlation of firing pin impressions. Each firing pin impression is sliced into layers; their circular cross-sections are converted into linear profiles by the polar coordinate transformation. The areal spline filter is used for extracting the high-frequency micro-features, or the individual characteristics, for accurate correlation.[6-8] Three identification parameters are proposed for determining whether these pair-wise firing pin impressions are fired from the same firearm. The Cross-Correlation Function (CCF) is used for quantifying similarity of the pair-wise profiles which represent the two correlated firing pin images. The registration phase angle θ is another important identification parameter: if the correlated cartridge pair is fired from the same firearm, there would be nearly a common phase registration angle between the set of profiles of the reference firing pin impression and those of the correlated firing pin impression. The vertical shift distance of the slice location h, combined with horizontal shift distance of the phase angle θ, are used for determining the congruency of the pair-wise correlated profiles. When these parameter values and their statistical distributions are collected for analysis, the CMX number is derived as a key parameter for a conclusive identification of exclusion.

The CMX method and the proposed identification algorithm were validated by 780 pair-wise firing pin topography images of 40 cartridge cases of three brands, which were fired from ten firearms from three different manufacturers. This includes 60 KM and 720 KNM image pairs. All of these topography image pairs are correctly identified based on the optimized parameters. There is a clear separation between the CMX distribution of the KM and KNM image pairs: for the 720 KNM image pairs, the CMXs are distributed from 0 to 14; for the 60 KM image pairs, CMXs are distributed from 20 to 49.[9] Although there is only a limited data size collected from three brands of 40 cartridges fired by ten firearms from three manufacturers in this study, it has demonstrated the possibility of using the proposed CMX method for correlations of large data sets of firing pin images fired from different firearms.

*Presenting Author

Reference(s):

1. Ballistic Imaging. The National Research Council (2008), p81-p85, p20 and p68.
2. Strengthening Forensic Science in the United States: A Path Forward. The National Research Council (2009), p6-2, p5-20, p6-2, p6-5 and p3-18.
3. Song J. Proposed NIST ballistics identification system (NBIS) using 3D topography measurements on correlation cells. *AFTE Journal* 45, 2 (2013), 184-189.
4. Song J. Proposed "Congruent Matching Cells (CMC)" method for ballistic identification and error rate estimation, *AFTE Journal*, 47, 3 (2015), 177-185.
5. Chu W., Tong M., Song J. Validation Tests for the Congruent Matching Cells (CMC) Method Using Cartridge Cases Fired with Consecutively Manufactured Pistol Slides. *AFTE Journal*, 45, 4 (2013), 361-366.
6. Zhang H., Ott D., Song J., Tong M., Chu W. A simple and fast spline filtering algorithm for surface metrology. *J. Res. Natl. Inst. Stand. Technol.* 120, (2015), 129-137.
7. Tong M., Zhang H., Ott D., Zhao X., Song J. Analysis of the Boundary Conditions of the Spline Filter, G2015-0975, to be published in *Measurement Science and Technology* (in press).
8. Zhang H., Tong M., Chu W. An Areal Isotropic Spline Filter for Surface Metrology. *J. Res. Natl. Inst. Stand. Technol.* 120, (2015), 64-73.
9. Zhang H., Song J., Tong M., Chu W. Correlation of Firing Pin Impressions Based on Congruent Matching Cross-sections (CMX) Method, to be published.

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*Presenting Author