Accepted Manuscript

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PII: S0379-0738(17)30342-0
DOI: http://dx.doi.org/10.1016/j.forsciint.2017.08.033
Reference: FSI 8976

To appear in: *FSI*

Received date: 19-4-2017
Revised date: 11-8-2017
Accepted date: 31-8-2017

Please cite this article as: Zhe Chen, John Song, Wei Chu, Johannes A.Soons, Xuezeng Zhao, A convergence algorithm for correlation of breech face images based on the congruent matching cells (CMC) method, Forensic Science Internationalhttp://dx.doi.org/10.1016/j.forsciint.2017.08.033

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ACCEPTED MANUSCRIPT

A convergence algorithm for correlation of breech face images based on the congruent matching cells (CMC) method

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Highlights

- Summarize the characteristics of existing Congruent Matching Cell (CMC) algorithms
- Exploit a convergence feature for the correlation patterns of breech face images
- A new CMC algorithm uses convergence to combine best features of existing ones
- Compare algorithms using breech face impressions with various class characteristics
- New algorithm significantly improves the separation between KM and KNM CMC scores

ABSTRACT
The Congruent Matching Cells (CMC) method was invented at the National Institute of Standards and Technology (NIST) for accurate firearm evidence identification and error rate estimation. The CMC method is based on the principle of discretization. The toolmark image of the reference sample is divided into correlation cells. Each cell is registered to the cell-sized area of the compared image that has maximum surface topography similarity. For each resulting cell pair, one parameter quantifies the similarity of the cell surface topography and three parameters quantify the pattern congruency of the registration position and orientation. An identification (declared match) requires a significant number of CMCs, that is, cell pairs that meet both similarity and pattern congruency requirements. The use of cell correlations reduces the effects of "invalid regions" in the compared image pairs and increases the correlation accuracy. The identification accuracy of the CMC method can be further improved by considering a feature named "convergence," that is, the tendency of the *x-y* registration positions of the correlated cell pairs to converge at the correct registration angle when comparing same-source samples at different relative orientations. In this paper, the difference of the convergence feature between known matching (KM) and known non-matching (KNM) image pairs is characterized, based on which an improved algorithm is developed for breech face image correlations using the CMC method. Its advantage is demonstrated by comparison with three existing CMC algorithms using four datasets. The datasets address three different brands of consecutively manufactured pistol slides, with significant differences in the distribution overlap of cell pair topography similarity for KM and KNM image pairs. For the same CMC threshold values, the convergence algorithm demonstrates noticeably improved results by reducing the number of false-positive or false-negative CMCs in a comparison.

Keywords:
Forensics
Ballistics
Firearm evidence identification
Cartridge case
Congruent Matching Cells (CMC)
Convergence

1. Introduction

The parts of a firearm that make forcible contact with a cartridge case, such as firing pin, breech face and ejector, create toolmarks on the surface of the cartridge case [1], in firearm identification, these toolmarks are compared to assess whether two cartridge cases were fired from the same firearm. One challenge for the identification of breech face impressions is that, depending on the contact situation during firing, not all the regions of the samples may have been well impressed by the firearm breech face. The overall

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