B108 Fingerprint Identification and Error-Rate Estimation Based on the Congruent Matching Cell (CMC) Method

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After attending this presentation, attendees will learn how to discriminate between matching and non-matching fingerprint image pairs by determining congruency of cell pairs divided from the original fingerprint image pair, as well as the error-rate estimation procedure.

This presentation will impact the forensic science community by providing fundamental scientific and statistical support to fingerprint identification.

The CMC method is an approach originally developed at the National Institute of Standards and Technology (NIST) for the accurate forensic identification of firearm tool marks. The CMC method is applied in fingerprint identification, aiding in the evaluation of the strength of fingerprint evidence by providing a technique to determine the random match probability of fingerprint evidence as well as the probability of false positives and negatives. In this presentation, promising initial results on the application of the CMC method to fingerprint identification are described.

The CMC method for comparing two samples is based on the correlation of pairs of small cells instead of the entire sample. Two sets of cells are a congruent matching pair if they have a high degree of similarity, typically expressed by the maximum value of the area Cross-Correlation Function (CCF_{max}) and if their registration position and orientation are consistent with those of other congruent cells. Thus there are three sets of parameters identifying cell pairs originating from the same source: (1) the CCF_{max} value; (2) registration position x and y; and, (3) registration angle θ, with associated thresholds T_{CCF}, T_x, Ty, and T_θ. An identification requires a certain minimum number of CMCs. It was observed that the correlation of cells instead of the entire surface yields a good statistical separation between the number of CMCs for matching and non-matching samples, even if major sample areas have missing features. The CMC method also enables an approach to estimating error rates. The combined false positive and false negative identification probability for each correlated cell pair, P_1 and P_2, can be estimated from the statistical distributions of the three sets of identification parameters and their thresholds. These probabilities are then used to estimate the probability of a false exclusion or false identification for a given number of compared cells and observed CMCs.

After modifications, the CMC method was applied to fingerprint identification. Forty-four fingerprint images randomly selected from the NIST fingerprint (10-print) database were compared. Each fingerprint image was divided into a cell array with an average of 225 cells. The number of CMCs for the 924 Known Non-Matching (KNM) fingerprint pairs were distributed in a range from 0 to 5. The number of CMCs for the 22 Known Matching (KM) fingerprint pairs were distributed in a range from 8 to 60. The initial results show significant separation between the KM and KNM CMC distributions and no false identifications or false exclusions were made. This study hopes to obtain a wider separation after tailoring the registration algorithms and CMC criteria to fingerprint patterns. Error-rate estimation will require tests on larger and more varied fingerprint sets to estimate typical "local" cell-matching probabilities in the patterns for images of various quality levels. It avoids errors introduced by incorrect feature identification, which lowers identification accuracy when comparing imperfect fingerprint images.

Fingerprint Identification, Error Rate, Congruent Matching Cells

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