A105 Bullet and Cartridge Case Signature Identification Using Topography Measurements and Correlations: The Unification of Microscopic and Mathematical Comparisons

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After attending the presentation, attendees will understand the methods in both microscopic comparison and identification of bullets and cases, combined with 3D surface topography measurement and correlations. The results of blind testing of bullets fired from ten consecutively rifled barrels and ten consecutively manufactured slides will be presented.

This presentation will impact the forensic science community by building onto current firearm identifications based on image comparisons using optical comparison microscopes. Because ballistic signatures are geometrical micro-topographies by nature, the main objective is to demonstrate the usefulness of surface topography measurement techniques for firearm identification. These results provide an objective mathematical validation of identifications that is in harmony with the results of optical comparison microscopy employed by an experienced firearms examiner.

Methodology: A 2D and 3D Topography Measurement and Correlation System was developed at NIST for certification of NIST Standard Reference Material (SRM) 2460/2461 Bullets and Cartridge Cases. Based on this system, a prototype system for signature measurement and correlation of fired bullets has been recently developed at NIST for bullet identifications. The 3D topography data of the land engraved areas (LEAs) of fired bullets are captured by a commercial Nipkow disc confocal microscope. The LEAs were processed by the "edge detection" method to determine the "striation density" by which the surface area with low striation density on the LEA could be masked out from correlation. The modified 3D micro-topography data on the remaining "valid correlation areas" are compressed into a 2D profile which represents the 2D ballistics signature of the LEA. A correlation program using two methods has been developed for matching the paired profile signatures: the "CMS" (Consecutive Matching Striae) method used by many firearm examiners and the CCF_{max} (cross correlation function maximum) method developed by NIST based on analysis methods in surface metrology.

Cartridge cases that comprised test fires from ten consecutively manufactured pistol slides, fifteen unknown cases, and five "persistence study" cases examined and measured. The cases were microscopically examined, and the results were later confirmed as accurately associating all of the questioned cases back to the correct pistol slide sources. A Nipkow disc confocal microscope was used to gather the 3D topography data from the breech face area of each case. The software applied the cross correlation algorithm to quantify the similarity between two cases.

Results: A set of 20 known-matching bullets fired from ten consecutively manufactured barrels (two bullets from each barrel) were tested. Their 3D topography images were captured by the confocal microscope at NIST, and correlated by the prototype ballistics identification system using the cross-correlation function maximum (CCF_{max}) as a correlation indicator. The correlation result was excellent: correlation values of all ten pairs of known-matching bullets scored highest on all correlation lists, yielding a correct identification rate of 100%. For the 60 pairs of matched LEAs (each bullet includes six LEAs), correlation values of matching LEAs scored highest on 59 out of 60 correlation lists, yielding a correct identification rate for individual LEAs of 98.3 %.

An additional set of 15 unknown matching bullets fired from the same set of ten barrels was blind tested. These bullets were correlated with the 20 known-matching bullets mentioned above. Both the CCF and CMS method were used and showed excellent correlation results. When using the CMS method, one matching pair did not meet the selected CMS criterion (3X) for a "match," and 29 out of 30 pairs of matching bullets were correctly identified, yielding a correct identification rate of 96.7%. When using the CCF method, all 30 pairs of matching bullets scored at the topmost position on their respective correlation lists, yielding a correct identification rate of 100

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Using statistical analysis from the known match and known non-match correlations, a baseline cross correlation function *(CCF)* was established to identify matches. Based on the *CCF* results, and a statistical analysis of the match and non-match case scores, each of the 19 of the 20 unknown cases were correctly identified to the slides that it came from. One case was not identified back to its original slide and had an "inconclusive" scoring. However, this one case was identified to other unknown cases that were correctly identified to the same slide.

Firearm, Topography, Comparison