A169 2D/3D Topography Comparisons of Tool Marks Generated by Ten Consecutively Manufactured Chisels and Drift Punches

Xiaoyu A. Zheng, MS, 100 Bureau Drive, Mail Stop 8212, Gaithersburg, MD 20899; Robert M. Thompson, BS, NIST, OLES, 100 Bureau Drive, MS 8102, Gaithersburg, MD 20899; and Johannes A. Soons, PhD, NIST, 100 Bureau Drive, Mailstop 8223, Gaithersburg, MD 20899*

The goal of this presentation is to evaluate whether a mathematically objective metric, the maximum value (CCF_{max}) of the Cross Correlation Function, can be used to identify a tool that generated a striated or impressed tool mark. The metric will be applied to the measured surface topography of tool marks generated under laboratory conditions on pristine surfaces. The study addresses the two types of tool marks and tools that produce them: chisels for the production of striated tool marks, and punches for the production of impressed tool marks. The study produced tool marks in a randomized fashion, and the results were tabulated blindly using an automated data analysis and identification system.

This presentation will impact the forensic science community by providing validation to the science of tool mark identification through the use of an objective identification method and criterion. Using these statistical methods, key recommendations in the 2009 National Academy of Sciences Report are addressed.[1]

A tool mark is created when plastic deformation and/or displacement is caused in a soft material by a tool. Tool marks generally appear in two forms: striated and impressed. Striated tool marks are formed when a tool-working surface is placed on another surface and moved parallel to that surface. Impressed tool marks are formed when the tool surface is forced perpendicular into another surface.[2] Consecutively manufactured tools have the most likely chance of producing similar tool marks, which have the greatest possibility of causing false-positive identifications. Ten consecutively manufactured chisels and punches were obtained from Western Forge (a supplier of Craftsman® Tools). The tools were separated into striated tool marks generated by the chisels and impressed tool marks generated by the punches. For each of the 10½" (12.7mm) chisels, a set of two known tool marks were created on a polished copper plate through a controlled dragging motion of the chisel produced by a motorized jig. After the identities of the chisels were randomized and hidden, an additional set of 20 unknown tool marks (two marks per chisel) were created. For each tool mark, a 2D stylus probe instrument was used to measure the surface topography along a line orthogonal to the striations. A total of 1,600 profile comparisons were performed in a 40 x 40 matrix. For each comparison, the two profiles were automatically registered to obtain the maximum value (CCF_{max}) of the Cross Correlation Function. The CCF_{max} values for the known match and known non-match comparisons were used to establish test statistics for the reliable identification of the unknown tool marks based on CCF_{max} values.

For each of the ten punches, a set of two known tool marks were created on a polished copper plate through a controlled drop of the punch, which was mounted on a linear rail. After the identities of the punches were randomized and hidden, a set of 20 unknown tool marks (two marks per punch) were created. A disk-scanning confocal microscope was used to measure the 3D topography of the tool marks. The data were then trimmed to remove any uninformative areas. Before the comparisons, each measurement was automatically pre-processed. Dropouts and outliers, which typically occur in areas of low reflectivity or high slope variations, were identified and masked. A total of 1,600 surface comparisons were performed in a 40 x 40 matrix. For each comparison, the pre-processed data sets were automatically registered in position and orientation to obtain the maximum value ($ACCF_{max}$) of the Areal Cross Correlation Function. The known match and known non-match $ACCF_{max}$ values were used to establish test statistics for the reliable identification of the unknown tool marks based on $ACCF_{max}$ values.

In a blind study of ten consecutively manufactured chisels and punches, the maximum value (CCF_{max}) of the Cross Correlation Function was successfully applied to link the measured surface topography of a tool mark to the tool that created it. All of the unknown striated chisel tool marks and impressed punch tool marks were correctly identified back to the tool that created them. These results provide an objective mathematical validation of the science for both striated and impressed tool mark comparisons.

References:

[1]National Research Council, Strengthening Forensic Science in the United States: A Path Forward, The National Academies Press, Washington, DC, 2009.

1. Thompson R, Firearm Identification in the Forensic Laboratory, National District Attorney's Association NIJ Grant 2008-MU-MU-K004, 2008.

** Presenting Author*

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