A205 Computational Pattern Recognition of Striation Patterns on Fired Cartridge Cases and Chisel Striation Patterns

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After attending this presentation, attendees will be able to appreciate the need for establishing a rigorous scientific basis for impression evidence comparisons.

This presentation will impact the forensic science community by giving a better understanding of how statistical pattern recognition techniques can be applied to striation and impression patterns left by firearms and tools and how these methods can be used to establish error rates of identification for evidence collected from crime scenes.

Forensic tool mark comparisons have received much attention in the last decade, especially since the publication of the National Academy of Sciences 2009 Report, "*Strengthening Forensic Science in the United States: A Path Forward*." One of the major criticisms is that there is no accepted methodology to generate numerical proof that independently corroborates morphological conclusions in questioned tool mark impression examinations. This researched focuses on answering that criticism by developing standardized methodologies to study and critically evaluate impression evidence.

Primer shear marks from forty-five, 9 mm cartridge cases fired from four Glock model 19 pistols (Glock 19s) have been collected along with fifty striation patterns made in lead with five consecutively manufactured chisels. Three-dimensional surface topography data from these collective striation patterns was obtained with high-resolution white light confocal microscopy using a 50x objective (0.95 NA) for the primer shear marks and a 20x objective (0.6 NA) for the chisel striation patterns. All topographies were preprocessed with outlier and form removal. Filtration into "waviness surfaces" extracted the essential "line" information familiar to forensic firearms and tool mark examiners. A cubic spline filter (ISO/TS 16610-22 standard) with a 0.08 mm wavelength cutoff was used to extract all waviness surfaces.

The primer shear topographies were summarized by taking the mean of all the profiles that made up the surface (i.e., mean waviness profiles of the primer shear marks were obtained). The profiles typically consisted of upwards of 2,500 points, which statistically were treated as random variables in a very high dimensional data space. In order to reduce the dimensionality of the data set, the profiles were subjected to principal component analysis (PCA) to obtain "synthetic" features of much more manageable size, but which still contain most of the topographical information in the original profiles. Next, support vector machine (SVM) algorithms were used to build a supervised learning model for the classification of each profile to a Glock. Effectively, this computational procedure testably "identifies" a primer shear mark as having been made by a particular gun. Both PCA and SVM methods were chosen for the statistical analysis because they are relatively free of assumptions on the statistical distribution of the data on which they are used and have been extensively applied with success in many industries requiring robust statistical discrimination systems. Also, they have a long peer-reviewed history in the scientific literature and produce easily testable (i.e. falsifiable) predictions, both of which become important issues when these methods are applied to evidence in a case subject to the *Daubert* standard. Finally, the statistical analysis programs written and used in the study are all open sources and available to anyone.

Using 200 bootstrap resampling iterations, PCA-SVM required only five "synthetic" features (5D) to produce an estimated identification error rate (refined bootstrap method used) of 0.2% on a larger data set of assumed similar statistical properties. The more conservative .632 bootstrap estimate yielded a 0.4% identification error rate estimate on a larger dataset (same assumptions). Pattern recognition results from chisel striation patterns treated in the same way as the primer shear marks will also be presented. The preliminary results of this research lend strong credibility to the fundamental principle of firearms and tool mark identification: that the striations imparted by the action of a tool on a softer surface are unique to that tool.

Statistics, Primer Shear, Striation Pattern

 ** Presenting Author*