A118 A Statistical Approach to Discrimination and Match Capability to Provide Scientific Basis for Estimating Significance of Fiber Association in Forensic Practice

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After attending this presentation, attendees will be introduced to the statistical significance of measurement variance of like and unlike fibers and will learn how the estimations of match significance can be made from fiber evidence. This is conducted through the use of multivariate statistical analysis and the product rule of independent variables.

This presentation will impact the forensic science community by demonstrating sources of variability and decision-making processes gained from this research that will serve to advance the forensic significance of class evidence involving fiber examinations.

The presentation will show how to increase the ability to classify and discriminate synthetic and cotton fibers. A library of over 800 well characterized fibers was developed with known dye components. Using visual light microscopy, visible Microspectrophotometry (MSP), and Fourier transform infrared spectroscopy, data was collected on fibers. In this report, studies were done on twenty-one red cotton and twenty-one red acrylic fibers using multivariate analysis. The absorption spectra of fibers from 10 replicate visible microspectrophotometry scans on each fiber were compared by using Principal Component (PCA) and Linear Discriminant Analysis (LDA). The software used in this work was developed at the University of South Carolina. PCA is used to find the directions of maximum variability to reduce the data dimensionality and enable use of LDA to provide projection maps of the data providing best discrimination of fiber groups. After projection into a two- or three-dimensional discriminant maps, discrimination of fiber groups can be judged visually by drawing 95% confidence limit ellipses around each group of points representing replicate spectra from the same fiber. Additional statistical hypothesis testing with Hotelling's T^2 test for the equality of means can be employed as a match criterion. With the aid of multivariate statistics, fibers that are difficult to distinguish by visual comparison can be distinguished. All 21 red cotton fibers, with the exception of two fibers, were distinguished by either PCA or LDA. The two that were not totally separated had the same dyes, but one of the fibers had a finish on its surface. PCA and LDA were also used to compare like fibers to determine how well fiber color matched on similarly dyed fibers. Separate samplings of the same red fiber measured seven weeks and two days apart showed large overlap and high correlation coefficients, thus providing quantitative match criteria. PCA and LDA provided a statistical basis to show the variance of like sample measurements and the discriminating capability of similar but different data. The next step required is to determine the probability of two statistically matched materials, based on measurements, as having come from the same source.

The "gold standard" in forensic science is the approach used in DNA matching by calculating the probability of occurrence of a given combination of alleles in short tandem repeats by the product rule of probability. By knowing the number of fibers in the database with specific color, diameter, cross-sectional shape, and chemical composition, the occurrence percentage of each fiber was determined. The product of the percentages was then calculated to determine the probability of two fibers matching randomly with those characteristics. Probabilities on the order of one in 0.5 million were obtained with such comparisons between fibers, and are valid, provided a sufficiently large and representative database of fiber characteristics is accessible. The improved understanding of sources of variability and decision-making processes gained from this research will serve to advance the forensic significance of class evidence involving fiber examinations.

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