B153 Examination of Statistical Methods for Forensic Analysis of Highly Similar Absorbance Spectra From Textile Fibers

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After attending this presentation, attendees will understand the application of objective statistical methods of analysis for the comparison of highly similar textile fibers using microspectrophotometry.

This presentation will impact the forensic science community by providing error rates for the methods described.

A question for fiber analysis with regard to forensic science is: can a Questioned (Q) fiber be associated with a Known (K) source or not? When the Q and K fibers exhibit obvious differences in physical, optical, and chemical characteristics, fiber discrimination by traditional methods is straightforward. Issues may arise when the Q and K fibers originate from highly similar sources which may lead to false non-discrimination decisions during analysis. The goal of this research is to investigate the rates of discrimination between fibers of sources that are highly similar in color. Principal Component Analysis (PCA) was utilized for dimension reduction since this study deals with large multivariate datasets. Discrimination was based on a combination of the score and orthogonal distances at a specified cutoff value.

The samples for this study originate from three different datasets. The first dataset consists of six 10-gram swatches purchased from and dyed on-site by a third party. The fabric samples include two identical swatches of nylon, two identical swatches of acetate satin, and two identical swatches of acrylic. The dyestuffs were chosen in pairs based on molecular structure. Dyes pairs include ACID BLUE (AB) 25 and 41, Disperse Blue (DB) 3 and 14, and Basic Green (BG) 1 and 4. Nylon swatches were dyed with AB 25 and 41, respectively; acetate satin swatches were dyed with DB 3 and 14, respectively; and acrylic swatches were dyed with BG 1 and 4, respectively. A total of ten fibers were sampled from different areas of each of the swatches, and 15 absorption spectra were collected from each fiber via microspectrophotometry. The individual spectra collected from each fiber were averaged. The second dataset consists of five commercially available blue acrylic yarns purchased from local craft retailers. Yarns that are visually similar with regard to color and shade were purchased. Two pairs of yarns shared the same brand name but were labeled as different shades of the same color as specified by the manufacturer. Dye composition information is unknown for the yarn samples. For the yarns, five fibers were sampled from each and 30 spectra were collected from each fiber.[1] Again, the individual spectra from each fiber were averaged. The third dataset consists of six 100% cotton denims purchased from local craft retailers. Again, dye concentration information for denim samples is unknown. From each of the denims, eight dyed fibers were sampled and 15 spectra were collected along the length of each fiber. Averaged spectra were calculated for each fiber.

Averaged spectra were subjected to PCA for dimensionality reduction. Either the number of Principal Components (PCs) that retain at least 95% of the variance of the original dataset or the first two PCs were kept for further statistical calculations. Hold-one-out cross validation comparisons were performed for this study with regard to same sample (within source) and different sample (between source) comparisons. When a Q spectrum is projected into the K principal component space a score value is calculated based on the score and orthogonal distance, the respective cutoff values, and an optimization parameter, γ, which ranges from zero to one. The Q spectrum is discriminated from the K spectra when the score value is greater than one.

Optimized results for the test swatches are as follows: same sample-7.5% discrimination; different sample-100% discrimination. Results for the yarns are as follows: same sample-16% discrimination; different sample-100% discrimination. Results for the denims are as follows: same sample-10.7% discrimination; different sample-76.5% discrimination.

This work was supported in part by the National Institute of Justice, Office of Justice Programs, award 2011-DN-BX-K553. The content of this publication does not necessarily reflect the position or the policy of the United States Government and no official endorsement should be inferred.

Reference:

1. White KM. Statistical Analysis of Visible Absorption Spectra and Mass Spectra Obtained From Dyed Textile Fibers. Orlando: University of Central Florida, 2010.

Fiber Analysis, Microspectrophotometry, Chemometrics