A198 Nonparametric Permutation Hypothesis Testing: Applications to Physical Evidence

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The goal of this presentation is to introduce the audience to nonparametric permutation testing which frees the analyst from distributional assumptions, and to demonstrate the application of the method to physical evidence evaluation.

This presentation will impact the forensic science community by demonstrating methods in which physical evidence is evaluated in the laboratory and presented in court.

This presentation will provide an overview of a nonparametric permutation hypothesis testing methodology and demonstrate the application of the method to laser-induced breakdown spectroscopy (LIBS) analysis of paint and glass samples, and analysis of fiber evidence by microspectrophotometry.[1-3] Research results will be presented and a method for reduction to practice will be described. The methodology described in this presentation directly addresses the need for improved statistical assessment of physical evidence.

Parametric statistical tests often rely on the assumption of normality which frequently does not hold for experimental data and the robust nature of the statistical test is relied upon to insure reliable results.

Nonparametric tests free the analyst from rigid distributional assumptions. The nonparametric permutation test exhibits excellent discriminating power for the physical evidence analyses mentioned above and rigorously holds the actual size of the Type I error at the nominal level.

The nonparametric permutation test has been applied to multivariate data sets comprised of spectral profile representations of the samples. Multiple spectra from each of two samples are compared through a similarity metric (i.e., Fisher transformations of Pearson product moment correlation coefficients). The difference between the sums of the similarity metric within spectral groups and between spectral groups, W_n, is calculated for all *n* permutations of the set of spectra. The fraction of W_n greater than or equal to the original spectral grouping, W_0, is a measure of the p-value for the test.

Results from laboratory tests of glass, paint and fiber analyses show that the test is sensitive enough to detect within-sample variations at a prescribed significance level (i.e., $\alpha = 0.05$). An example of LIBS analyses of glass samples is shown in Figure 1. Analyses were conducted in five different areas on each of ten different automobile side windows. Twenty comparisons each were made between all same window-same area (SWSA), same window – different area (SWDA) and different window (DW) samples, for a total of 4,100 comparisons. The distributions of the p-values for each set of comparisons are shown as box plots in Figure 1. The SWSA p-values are randomly drawn from a uniform distribution with 3.5% of the values less than or equal to 0.05 (i.e., 3.5% Type I error which is near the nominal $\alpha = 0.05$). A total of 54.8% of the SWDA p-values fell below 0.05, indicating a significant discrimination between different areas of the same window. Substantial variation of elemental concentration within float glass panes has been reported based on LA-ICP-MS analyses.[4] A total of 98.7% of the DW comparisons gave p-values below 0.05 (i.e., a 1.3% Type II error rate), reflecting the excellent power of the test. A methodology will be described which combines the nonparametric permutation test with a Wilcoxon rank sum test to allow the nonparametric permutation method to be effectively applied to casework samples.

All calculations were performed using software written in-house.

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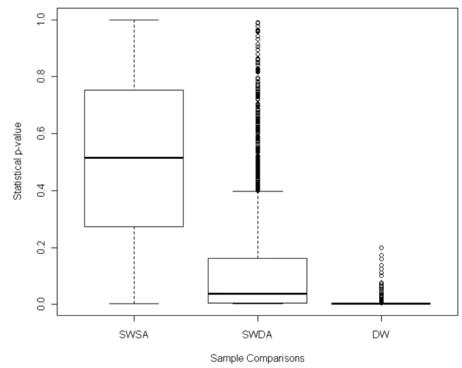

Figure 2. Statistical p-value distributions from the comparison of LIBS spectra taken from the same window-same area (SWSA), same window-different area (SWDA) and different windows of automotive side windows.

References:

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