B154 The Calculation of Likelihood Ratios in Fire Debris Analysis: Model Effects

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After attending this presentation, attendees will better understand modern methods of fire debris analysis, the calculation of Likelihood Ratios (LLRs) and how model effects on the LLR can be taken into account. Model effects on the LLRs calculated for fire debris samples can arise through distributional changes, which may have an impact on the class means, variances, and covariances of the model.

This presentation will impact the forensic science community by helping analysts understand how to implement models based on a relevant population and statistical sampling of a database.

A simple method is presented for the calculation of LLRs for fire debris samples. The method involves statistically sampling a database of ignitable liquids and substrate pyrolysis data in proportion to the estimated class distribution in a relevant population. The sample of ignitable liquid and substrate pyrolysis data will form the basis for calculating class means, variances, and covariances to be use in a kernel density estimate of the LLR for a fire debris sample. The multivariate kernel density is calculated from a limited feature set comprised of the scores for the first four principal components, which are derived from principal component analysis of the statistically sampled data. Multiple models are prepared by repeated sampling of the database. Bootstrap validation was calculated for each model and the average area under the Receiver Operating Characteristic (ROC) curve was taken as a measure of model performance.

Ten models were prepared for each of three population distributions. Each of the models had an average area under the ROC curve of greater than 0.9. The models were used to estimate the evidentiary value for a set of laboratory burns. One set of burns involved polyester carpet and padding with added gasoline. Samples were burned for time periods of 0.5 minute, 1 minute, 2 minutes, 3 minutes, and 5 minutes. A set of samples containing polyester carpet and padding with added medium petroleum distillate were burned for the same time periods. A set of polyester carpet and padding samples without added ignitable liquid were also burned for the same time periods. The base 10 log of the LLRs for all samples were in the range of 2 to -2, which are considered reasonable. The LLR values for the samples containing ignitable liquid were observed to be positive at early burn times and proceeded to become negative at longer burn times as the solvent was weathered and pyrolysis products were produced in the burn.

The method discussed is considered suitable for casework samples. The method allows the analyst to report the evidentiary value of fire debris samples as numerical (LLR) values.

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Fire Debris, Likelihood Ratio, Database