B128 Bridging the Gap Between Categorical and Probabilistic Statements in Fire Debris Analysis

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After attending this presentation, attendees will better understand Receiver Operating Characteristic (ROC) curves and how they depict the relationships between categorical decisions and evidentiary value.

This presentation will impact the forensic science community by exploring these and other relationships between categorical decision thresholds and likelihood ratios as applied to fire debris evidence.

The paradigm shift from categorical statements to statements of evidentiary value are facilitated by ROC curves and the visual representation they provide of the relationships between the strength of the evidence, decision risk and cost, and other related parameters.

A categorical statement implies that a decision has been made regarding some aspects of a forensic examination. For example, it may be categorically stated that a fire debris sample contains residue of an ignitable liquid from one of the American Society for Testing and Materials (ASTM) E1618 classes.[1] When a categorical statement is made, it is also implicit that the analyst has set some threshold upon which the decision is based. Unfortunately, the current system of fire debris analysis does not define and implement a numerical scale for setting a decision threshold, and consequently analyst bias is possible. In addition, a categorical decision coupled with a variable decision threshold provides no information regarding the strength of the evidence. It is possible to understand the relationship between decision thresholds and evidentiary value with the assistance of the ROC curve.[2]

Generating a ROC curve requires assigning a score to each sample in a data set. The ground truth (positive or negative for ignitable liquid) must be known for each sample. Samples of known ground truth can be generated in the laboratory; however, the samples must be realistic and representative of casework samples. Assigning a score to each sample is the more complicated task. The score should be a single value and should reflect the probability that a sample belongs to the positive class (i.e., those samples containing ignitable liquid residue). Samples containing a more prominent ignitable liquid profile should receive a higher score. The scores can come from numerical calculations, the application of rules lists, decision trees, or other methods.[3] Once a scoring method has been determined, it is applied to all the samples in the known ground truth data set and each sample is assigned a score. Since the ground truth is known for each sample, along with an assigned score, it is easy to generate a ROC curve by using each score as a threshold and assigning each sample with a score greater than or equal to the threshold as belonging to the positive class. Once the class assignment is made, calculate the true positive and false positive rates and plot these values on an x, y coordinate system. After stepping through all of the possible thresholds, the points are connected to generate the ROC curve. The tangent to the ROC curve at any score gives the likelihood ratio for samples with that score. The slope of a line from the origin (0, 0) through a point on the curve that has been defined as a decision threshold corresponds to the likelihood ratio for all decisions based on that thresholding score.[4]

These and other relationships between categorical decision thresholds and likelihood ratios will be explored for fire debris evidence.

Reference(s):

1. Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry. *ASTM International.* 2014.
2. T. Fawcett. An introduction to ROC analysis. *Pattern Recogn. Lett.* 27(8) (2006) 861-874.
3. M.E. Sigman, M.R. Williams. Assessing evidentiary value in fire debris analysis by chemometric and likelihood ratio approaches. *Forensic Sci Int*. 264 (2016) 113-21.
4. B.C.K. Choi. Slopes of a Receiver Operating Characteristic Curve and Likelihood Ratios for a Diagnostic Test. *American Journal of Epidemiology*. 148(11) (1998) 1127-1132.

Fire Debris, Likelihood Ratios, ROC Analysis

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