B34 Creating a Bayesian Network Using Normalized IBIS Scores of .357 Magnum® and .38 Special Cartridge Cases

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After attending this presentation, attendees will understand that transformations through normalization of the correlation scores of the firing pin and breech face influence the likelihood ratio. The Receiver Operator Curves (ROCs) of the firing pin and breech face ranks, including the product of the two, are different from the normalized ROCs of the firing pin, breech face, and their product. A firearms examiner can make a more informed decision by using normalized Integrated Ballistic Identification System® (IBIS®) scores.

This presentation will impact the forensic science community by demonstrating that transforming the IBIS® correlation scores through normalization affects the accuracy of the results. The generation of ROCs from both non-normalized and normalized data sets will show the influence that the variation in data has on the likelihood ratios.

The IBIS®, developed by Forensic Technology International, serves as the backbone of the National Integrated Ballistic Information Network (NIBIN) system.[1] This system allows for the databasing of images of cartridge cases and bullets. For each cartridge case, two areas are imaged: the firing pin impression and the breech face impression. All of the cartridge cases were entered into the 2D IBIS® system in order to generate the match data. The acquisition method followed was established in a previous study.[2] The data was mined to evaluate the variance between relationships involving the following variables: firing pin rank, breech face rank, make and model of the firearm, the ammunition used, caliber, and type of primer reload (if any).

The research involved the acquisition of .357 Magnum® and .38 Special revolver cartridge cases from 15 .357 Magnum® firearms and eight .38 Special firearms. The .357 Magnum® revolvers were used to fire both .38 Special and .357 Magnum® cartridges. The IBIS® compares unknown .38 Special cartridge cases to known (in the database) .38 Special and .357 Magnum® cartridge cases, but only compares unknown .357 Magnum® cases to known .357 Magnum® cases.

A ROC can be used to determine the crossovers between match and non-match. ROCs demonstrate the discriminating power of the method. Normalized and non-normalized ROCs were generated for each individual .38 Special and .357 Magnum® firearm used.

Normalization originates from statistics and eliminates the unit of measurement by transforming the data into new scores (Z-scores) with a mean of zero and a standard deviation of one.[3] Normalizing a set of scores involves subtracting the sample mean from the score and then dividing by the standard deviation of the sample. For the purpose of this research, the mean and standard deviation of a variety of sampling percentages of non-match scores for each firearm was found and then used to convert each cartridge case fired from that firearm to a Z-score. This was performed for firing pin, breech face, and their product.

A Bayesian network was used to determine the relationship between the IBIS® scores from the cartridge casings that were collected from the firearms in this study. Scores from IBIS®, such as Firing Pin (FP), Breech Face (BF), and rank (BF/FP) scores were included, as well as factors controlled by the analysts, such as the make/model of the firearms of a chosen caliber. Four new concepts were added as part of the network. They included: breech face rank, normalized firing pin and breech face scores, and the normalized multiplication of the two. The network includes a node titled "Match" and depending on what is instantiated in the network, the probability of a match fluctuates (this will be demonstrated using a computer while presenting). These match and non-match probabilities can then be used to calculate a likelihood ratio based on assigned prior odds. The match/non-match probabilities act in support of $P(H_p|E)$ (probability of the prosecutorial hypothesis being true, given the evidence) or P(Hd|E) (probability of the defense hypothesis being true, given the evidence), respectively.[4]

Transformation of the scores through normalization can lead to improved accuracy of results.

References:

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Firearms, Bayesian Networks, Normalization