B150 Investigative Predictions of Smokeless Powder Manufacturers

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After attending this presentation, attendees will understand how the application of a Bayesian network to smokeless powder's physical and chemical characteristics data from a database can provide probability-based estimates of the manufacturer.

This presentation will impact the forensic science community by providing an investigative tool with the ability to predict the manufacturer of a smokeless powder based on its physical and chemical properties.

This research proposes the use of a Bayesian network that utilizes data from the National Center for Forensic Science (NCFS) and the Technical/Scientific Working Group for Fire and Explosions (T/SWGFEX) Smokeless Powders Database to suggest, by means of posterior probabilities, the manufacturer of a smokeless powder based on its physical and chemical characteristics. The dataset, comprising 119 NCFS smokeless powder database samples, contains information pertaining to the manufacturer, color, shape, average diameter, average length, and six class-associated ions which were previously determined from cluster analysis. Bayesian network structures are referred to as Directed Acyclic Graphs (DAG), which are comprised of nodes and arcs. Nodes represent events or variables which can have multiple states. Arcs represent causal dependencies between the nodes and are directed from parent nodes to child nodes. Probability tables are associated with each node; a parent node table encodes prior probabilities and child node tables encode class-conditional probabilities.

Two network designs have been explored. The first network contains a parent node representing the manufacturer of the smokeless powder with nine child nodes representing color, shape, m/z46, m/z120, m/z134, m/z149, m/z165, and m/z169. The second network is similar to the first, but has two additional child nodes representing the average diameter and average length of the smokeless powder. The m/z ions characterize the chemical composition of the smokeless powder; each one is a base ion for a specific compound or group of compounds. The networks were constructed and manufacturer posterior probabilities calculated using R statistical computing software. Prediction performance was estimated based on 100 iterations in which each repetition randomly withheld 5% of the dataset for testing; the remaining 95% was used to train the network. Values in the probability tables were calculated based on frequencies in the training dataset.

The networks were instantiated by entering evidence in the child nodes for each smokeless powder sample in the test set, and the prior probabilities in the manufacturer node were updated to posterior probabilities after the evidence was observed. The manufacturer for each test sample was predicted based on the highest posterior probability. Overall percent correct rates were determined by calculating the number of correct predictions; that is, where the known and predicted manufacturer were the same. The networks achieved overall percent correct rates of 66% and 70% for NET 1 and NET 2, respectively. The overall percent correct rates are significantly larger than the 20% random assignment rate. Work is continuing to focus on improving the overall percent correct based on posterior probabilities.

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Smokeless Powders, Bayesian Networks, Database