B89 Practical Applications of Pattern Recognition to the Post-Blast Analysis of Black Electrical Tape

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After attending this presentation, attendees will understand the utility of using the statistical models Agglomerative Hierarchical Clustering (AHC), Principal Components Analysis (PCA), and Discriminant Analysis (DA) in identifying and comparing black electrical tape samples in a post-blast environment.

This presentation will impact the forensic community and/or humanity by demonstrating how statistical models can correctly assign samples of black electrical tape with their nominal brand in a post blast scenario.

Black electrical tape is commonly found at crime scenes and the brand identification and/or association of a sample back to its roll of origin can be paramount to the course of an investigation. In this study, the ability of multivariate statistical techniques to correctly identify and compare intact and post-blast tape samples was evaluated. An exemplar brand of black electrical tape was wrapped in multiple layers on the outside of three pipe bombs, and a second brand was located inside the devices, wrapped around plastic bags containing the propellant Pyrodex. Two of the bombs were initiated with electric matches, one of which was fumed with cyanoacrylate in the field. A third device was used as a control.

In the debris field, multiple pieces of electrical tape were found either on the pipes or nearby and ranged in size from fairly intact multi- layered tape fragments to small shards of extremely damaged single- layer tape. Most tape found consisted of at least two layers which, upon separation, allowed for testing of a relatively clean adhesive or backing surface. As a result, all collected fragments were amenable to chemical analysis with the exception of one badly damaged tape shard. The smallest of the useable fragments had an area of approximately one square centimeter. The backing portion of the tape fragments was cleaned using a clean cotton swab, while the adhesive side was picked as clean as possible using forceps. The backing portion was analyzed with Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS) and Fourier Transform Infrared Spectroscopy (FTIR), while the adhesive layer was analyzed only with FTIR. The elements identified via EDS in the tape backing were expressed as net peak areas. All elements that were present at or above the limit of quantitation of the instrument were normalized by summing the square of all peak areas for that sample and dividing each peak area by the square root of that sum. The FTIR data was also normalized using the sum of squares approach. The results were then evaluated using multivariate statistical models.

Using the averaged normalized data for both techniques, AHC was performed. This technique groups the data by its similarity/dissimilarity, placing similar samples in a single group while excluding others. An AHC dendrogram results, which shows families of tapes grouped together. PCA analysis further discriminates samples by expressing the variations in multi-dimensional data as principal components, the first few of which account for the majority of the data variation and can be plotted visually in two or three dimensions. Further analysis of the PCA data was done using DA, which utilizes a learning set of tape exemplars to optimize the grouping of the samples. DA can then assign unknown samples to a known brand of electrical tape, thus allowing for the identification of post-blast material.

An extensive collection of tape exemplars was used in this study, comprising over 80 rolls of 0.75 inch nominal width black electrical tape that represented over 30 nominal brands, 8 manufacturers, and 3 countries of origin. To allow for better discrimination, rolls were divided into two categories based on the color of their adhesive. Tapes with black adhesive were successfully differentiated by brand 89% of the time using SEM-EDS and subsequent evaluation by DA, with two brands having largely indistinguishable surface textures and elemental compositions. AHC analysis of FTIR data, on the other hand, was able to elucidate a difference between these two brands. The clear adhesive tapes were divided into those that do or do not contain aluminosilicate filler. For tapes that do not contain aluminosilicate filler, DA assigned the known rolls to the correct brand 98% of the time. For tapes that do contain aluminosilicate, DA assigned the correct brand 99% of the time. For the post-blast material, the two known tapes utilized were clear adhesive, non-aluminosilicate filler tapes. After detonation, seven samples ranging from one to five layers of tape were recovered. Based on SEM-EDS and FTIR analysis combined with multivariate statistical models, two of the multi-layer tape fragments were correctly assigned to tape brand applied to the exterior of the devices. The remaining five tape fragments were correctly assigned to the tape brand applied to the interior of the devices.

General statement of conclusion: Using multivariate statistical models, fragments of electrical tape found in a post-blast debris field were identified to their nominal brand.

Electrical Tape, Multivariate Statistics, Explosives