A199 Quantitative Algorithm for Digital Comparison of Torn Duct Tape

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After attending this presentation, attendees will understand some of the principles of objective, quantitative methods. These mathematical methods are currently in use by the academic engineering community, and can be applied to the area of physical matching in regards to duct tape examinations. The attendees will have greater appreciation for some of the complex tasks that can be conducted with modern digital imaging software.

This presentation will impact the forensic science community by establishing the first objective numerical methodology that can be successfully applied to physical matching of duct tape, its results meeting one of the key tenants of the NAS Report "*Strengthening Forensic Science in the United States: A Path Forward*."

The National Academy of Sciences (NAS) cited the need to establish the scientific basis demonstrating the validity of forensic science methods. In support of this, we have developed a quantitative algorithm for the digital comparison of torn and cut duct tape ends to evaluate their end match. This algorithm is programmed to perform a series of software routines that will result with each torn duct tape end profile displayed in a graphical format and then the profile of the torn duct tape end is compared to all the other duct tape specimens using residual analysis. The key idea of this research is that the true match will have a statistically significant lower sum of the squared residuals than all the other test specimens that do not match; the associated non-matching specimens will have much larger residual values. Having numerical results will enable us to derive meaningful statistical information that can describe significant differences between the matching and non-matching duct tape ends. This research involves the inter-comparison of samples from a set of 100 pairs of torn duct tape specimens. Inter-comparison of this set of 100 pairs resulted in 10,000 inter-comparisons. These torn duct tape specimens are also unique in that each of these specimens has been used in a previous statistical research study to look at end matches by four experienced Graduate Student Researchers (GSRs); these GSRs were required to inter-compare duct tape specimens as part of a training protocol. The GSRs had to identify those that matched and those that did not match within the set of 100 pairs of duct tape, which all four GSRs were able to do correctly. Using the quantitative mathematical algorithm, it is expected to provide numerical data correlating matching and non-matching specimens which can be related to the findings of the analyst. The end product of this research will be a quantitative and statistically rigorous guideline for end match comparison.

In this analysis, the left side of a torn tape specimen was called the "Exemplar" tape and it was compared to the right side of a torn tape specimen which was called the "Sample" tape. The procedure for processing each tape specimen consists of a series of steps beginning with scanning the specimens into the computer at 1,200 DPI. Next, using MATLAB®, the North and South boundaries of each tape are selected, followed by defining the torn area of interest. The algorithm then performs a series of image manipulation and provides a graphical profile of the torn ends. Due to minute thread fragments extending from the tape that can interfere with residual analysis, the algorithm performs a series of extraction and dilation routines on the torn profile. The Exemplar profiles are then compared to the 100 Sample profiles in the database using residual analysis. The hypothesis is that the pair of tapes with the lowest residual value (in $pixel^2 \times 10^6$) should be a matching pair in the set of 100 pairs of tapes. Research supported this hypothesis, in that a pair with the lowest residual values for the set was determined to be the matching pair. There are still many issues that could enhance future research in this area such as the "entropy of the torn specimen." The current algorithm treats each tear or cut in the same manner, but in reality a tape with a complex tear pattern is much more significant. This type of tape, because of its randomness, should be given a more unique residual value than a tape with a very simple tear pattern, even though the residual value for the two tapes could be similar. Although this development work used the engineering software MATLAB®, the end product will be an executable program that does not necessarily require the use of MATLAB®.

Duct Tape, Physical Matching, Image Analysis

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