B150 Quantitative Algorithm for Digital Comparison of Torn and Cut Duct Tape

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After attending this presentation, attendees will better understand minimizing human contextual bias via a quantitative imaging algorithm and corresponding mathematical methods to extract the edge profiles of torn and cut duct tape samples.

This presentation will impact the forensic science community by presenting information about a quantitative algorithm for the digital comparison of torn and cut duct tape.

The National Research Council (NRC) established a need at the national level for the validation of forensic science methods. Currently, duct tape end matching is based on human judgment with no quantitative criteria for identification. In this research, the needs of the forensic science community are met by minimizing human contextual bias with a quantitative algorithm. The detected edges of the exemplar and an arbitrarily large number of test samples are algorithmically subtracted from one another. The resulting residuals are then used to calculate the Sum of Squared Errors (SSE), a succinct metric that allows quantitative comparison of possible matches. A best or "most likely" match is determined by identification of the match with minimal SSE. The digital results are compared to a prior study of the same set of duct tapes that were visually assessed by a group of three researchers as part of an error determination study, thus providing a quantitative estimate of the respective error rates.

The MATLAB® software platform is used to code a series of mathematical functions in order to extract useful information from an image or a series of measurements. This research uses MATLAB® to obtain an edge profile of the duct tape image and performs analysis on the data. A digital image of the duct tape is collected using a high-resolution scanner at 1,200 Dots Per Inch (DPI). A digital profile of the tape is developed using the focused tear region and the parallel edges of the duct tape. The software performs a series of automated tasks. First, the software takes the selected image, sets threshold levels, and converts pixels to a binary image. Second, the software performs an ad hoc smoothing mechanism that removes the yarns by using a morphological operation that conducts erosion and dilation in order to remove the noise associated with the yarns. Last, the software converts the coordinate points into a graphical format and compares the edge profile to other edge profiles with a residual calculation that assesses the degree of difference along the focused tear region. The results are displayed on a bar and color map graph showing the difference of the SSE values for a matching piece of duct tape in comparison to the other duct tape pieces in the database. The user examines the residual calculations and determines whether one pair is quantitatively a better match than other pairs examined. The results establish that if other pairs of known matches have SSE values in the same range, it strongly suggests that it is the correct match. The duct tape database comprised of 2,200 paired duct tapes requires the analogies of 4,400 scanned duct tape images, making 19,360,000 inter-comparisons. Using this quantitative mathematical algorithm, the capability of the algorithm to identify matching specimens in sets of 200 duct tapes of a particular brand, to look at overall residue values by themselves as an indication of uniqueness, and to quantify the number of false positives and false negatives will be discussed. This study will compare and contrast the results with the findings of prior researchers who conducted a manual comparison of these same duct tape specimens. This prior study was presented at the 2011 American Academy of Forensic Sciences meeting by McCabe et. al.[1] The end product is a quantitative and statistically rigorous guideline for end-match comparison.

This research is funded by a grant from the Office of Justice Programs, National Institute of Justice award number # 2013-R2-CX-K009. The opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect those of the Department of Justice.

Reference:

1. McCabe, K. The statistical evaluation of torn duct tape physical matches, Proceedings of the American Academy of Forensic Sciences, 63rd Annual Scientific Meeting, Chicago, IL. 2011. Abstract A157 p.103.

Duct Tape, Physical Matching, Image Analysis