B213 Assessing the Value of a Physical End Match in Trace Evidence: A Comparison of Human-Based and Computational-Based Approaches

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Learning Overview: After attending this presentation, attendees will be informed regarding a developed systematic method for reporting the quality of a physical fit of duct tape edges, the results for inter- and intra-examiner variation in the reporting of a quantitative similarity score, and the comparison of human-based and computational-based approaches.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating the value of physical fits in trace evidence. This presentation will also demonstrate the development of a systematic method on duct tape and highlight future research that aims to expand the materials and methodologies applied to the analysis of edges to offer additional support to inform the examiner's expert opinion.

Physical match examinations have played a critical role in forensic science for many years and extend across many forensic disciplines. The analysis of a potential physical fit involves an examination of separated edges to determine if the compared items re-align with distinctive features. In trace evidence, physical fits represent the highest degree of association between two items of evidence. As such, many examinations end once a fit is discovered and documented. Currently, physical fit examinations are being appraised to introduce a more standard and systematic methodology to support the opinions of examiners.

This work expands on the research presented by the West Virginia University group at the 2019 American Academy of Forensic Science conference regarding the comparison of duct tape edges using a systematic and quantitative method through an increased sample set, additional methods of interpreting the data, and assessment of intra-examiner and inter-examiner variation. In this study, edge similarity scores were utilized to assess 2,500 duct tape edges of varying grade, separation method, and degree of stretching. Edge similarity scores were calculated as a relative ratio of observed matching sections per scrim area. The performance rates of the method were calculated, and the distributions of scores were assessed to interpret the quality of a fit between edges. Overall, the method produced accuracies of between 84.9%–99.8% for the different tapes sets, with no false positives reported. It was found that the grade of the tape had a substantial impact on the quality of a fit between edges.

The distributions of edges were assessed utilizing Receiver Operator Curves (ROCs), boxplots, kernel density functions, beta distributions, and score likelihood ratios, demonstrating that a score of 80% or higher indicates strong support for a match, while scores below 25% indicate strong support for a non-match. Intra-examiner and inter-examiner variation were evaluated on blind sets of tape ends and agreement better than 15% was observed between reported edge similarity scores. Additionally, a machine learning algorithm was developed to predict if images of two pieces of duct tape coincide. The algorithm is based on Artificial Neural Networks (ANN) using the open-source python package scikit-learn. To train and use the ANN, first, the connectivity pattern of the network was defined. The architecture is defined by the number of initial input nodes, number of hidden layers with their corresponding neurons, and, finally, the number of output neurons. In the preliminary architecture of the network, five hidden layers with 200 nodes in each layer were chosen, using a constant learning rate; 200 matched the torn images, and 200 images were classified as not matched. The training step used 80% of this data and the rest was used to evaluate the accuracy of the model. Within these parameters, accuracy of ~85% was achieved, which was comparable to the examiner's performance.

Physical End Matching, Trace Evidence, Duct Tape

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