OSAC RESEARCH NEEDS ASSESSMENT FORM

Title of research need: Assesment of Criteria for Meaningful Differences in Trace Materials Comparative Data

Keyword(s): Trace evidence, comparison criteria, meaningful differences

Submitting subcommittee(s): Materials/Trace

Date Approved: 9/24/18

Background Information:

1. Description of research need:

In trace evidence comparisons, the forensic examiner analyzes the evidence and resulting data, forms an opinion, and summarizes the findings in a written report. The examiner shall also interpret and report the overall meaning of those findings.

Most of the trace examinations involve a series of analytical steps to identify physical and chemical features that may indicate the compared items are dissimilar in their measured properties. Often, each of these examination stages involves a binary decision to determine whether or not the compared samples can be discriminated based on the measured data.

The data derived from the analysis can be qualitative (i.e., texture, color, identification of compounds from a chemical spectrum, location, and shape of a spectral peak), semi-quantitative (e.g., relative ratios of components in a mass spectra), or quantitative (e.g., concentration of chemical compounds, refractive index).

Criteria must first be established to define if there is a “meaningful difference.” For a difference to be meaningful, the feature or property of a sample should not fall within the variation exhibited by the comparison sample, considering the limitations of the sample or technique. When meaningful differences are found, they often support the proposition that the two samples do not share a common origin.

Examiners make use of validation studies to determine the instrumental variations and to set up quality control thresholds, survey studies to determine how discriminating the compared characteristics are, and reference collections and databases to assess the rarity of observed features based on within-sample and between-sample variations. Replicate measurements of the known and question samples are also needed to arrive at a decision.

Several of these studies have helped to establish comparison criteria in trace comparisons. However, the binary decision process does not always involve the formal application of statistical tests, and the decision of exclusion/association is often made based on cumulative knowledge and expertise of the examiner. This expertise is critical, but it will also benefit from complementary statistical support.

For instance, infrared analysis is one crucial step in the forensic examination and comparison of paint evidence. During the examination, the examiner acquires multiple measurements of each paint layer of the known sample and the questioned sample. First, the examiner interprets the FTIR spectra to identify the main components present in the paint layer (e.g., pigments, fillers, and binder). Then, the examiner compares the relative location and shape of the spectral peaks from the multiple measurements to determine if there are “meaningful differences.” This step is often conducted by the overlay of the spectra in a computer, but the examiner ultimately decides if there is a difference. The examiner’s expertise is critical to determine if the differences are within expected variations of the manufacture of the material or if they are anticipated based on the appearance of the items during the prior microscopical examination of the evidence. Still, it is a subjective decision, especially when the differences between samples are minor.

Some comparison algorithms have been developed for database searching of IR spectra (e.g., PDQ database, Bio-Rads’...
2. Key bibliographic references relating to this research need:


C Muehlethaler, G Massonnet, P Esseiva. The application of chemometrics on Infrared and Raman spectra as a tool for the forensic analysis of paints. Forensic science international 209 (1-3), 173-182

Cyril Muehlethaler, Geneviève Massonnet, Tacha Hicks. Evaluation of infrared spectra analyses using a likelihood ratio approach: A practical example of spray paint examination. Science and Justice 56(2):61-72


3a. In what ways would the research results improve current laboratory capabilities?

Crime laboratories require the development of standardized criteria to determine when differences in the observed or measured features of compared samples are found to be “meaningful.” This type of research will help in the harmonization and standardization of interpretation of trace evidence.

There is a vast amount of existing data derived from validation studies, surveys, and databases that could serve as a valuable source of data for the validation of comparison algorithms and models. A close collaboration between practitioners and statisticians is strongly recommended to optimize the outcomes of such research.

3b. In what ways would the research results improve understanding of the scientific basis for the subcommittee(s)?

At the subcommittee level, this type of research would provide additional support to the instrumental guides for all material types as well as interpretation and report writing guidelines that are being developed for trace materials in general.

3c. In what ways would the research results improve services to the criminal justice system?

The development of universal and automated statistical approaches for the comparison of data will enhance the scientific foundations of the interpretation of trace evidence materials. Ideally, the proposed statistical approaches could be expanded in the future to other forensic disciplines.

4. Status assessment (I, II, III, or IV):  

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<tr>
<th>Major gap in current knowledge</th>
<th>Minor gap in current knowledge</th>
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<tbody>
<tr>
<td>No or limited current research</td>
<td>I</td>
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This research need has been identified by one or more subcommittees of OSAC and is being provided as an informational resource to the community.

Approvals:

- **Subcommittee**
  - Approval date: 9/24/18
  - (Approval is by majority vote of subcommittee. Once approved, forward to SAC.)

- **SAC**
  - 1. Does the SAC agree with the research need? Yes [x] No [ ]
  - 2. Does the SAC agree with the status assessment? Yes [x] No [ ]
    - If no, what is the status assessment of the SAC: 
  - Approval date: 12/19/18
  - (Approval is by majority vote of SAC. Once approved, forward to NIST for posting.)