B160 Learning Algorithms to Evaluate Glass Evidence

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Learning Overview: After attending this presentation, participants will know about a new approach for analyzing and comparing glass evidence using the elemental concentrations in the glass. Participants will also learn how to access and use the database built by Iowa State University researchers, in collaboration with researchers at the University of Iowa.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by highlighting some limitations in the current methods to interpret glass evidence and by proposing an alternative approach to do so.

Glass evidence arises in criminal cases whenever a glass object such as a house window or a car windshield is broken. If glass fragments are recovered from the suspect, the question of interest is whether the fragments on the suspect could have originated from the broken item at the crime scene. With technology such as LA-ICP-MS, it is possible to measure the content of many elements in the glass with high precision. Using this information, researchers have proposed interval-based criteria to compare two glass fragments and decide whether they are chemically indistinguishable.[1,2] Roughly, these approaches use measurements from known fragments to compute univariate intervals around the elemental composition means and then declare that the question fragment has an indistinguishable chemical composition if all mean elemental concentrations fall within those intervals. Guidelines on the application of these methods are given in ASTM E2330 and ASTM E2927.[3,4]

A machine learning approach is proposed to compare two glass fragments for the purposes of classifying them as being indistinguishable (a "match") or not. The approach computes a similarity score for each pair of fragments using the difference in the content of 18 elements as "features." The features are combined into a single score via a random forest. The score takes on values between 0 and 1; the higher the score, the stronger the evidence in favor of a "match."

To construct and test the algorithms, a database of glass fragments has been created. At present, the database contains over 1,500 fragments, obtained from 48 different samples of float glass produced by two different U.S. manufacturers over a period of one month. Each glass sample was broken into fragments and 24 fragments from each sample were randomly selected for analysis. Measurements on each fragment were replicated 5 times, and for 3 fragments in each sample, the number of replicates was increased to 20. Thus, the database that has been created permits estimation of the variability in elemental composition at many different levels: within fragment (between replicates), within sample (between fragments), within manufacturer (between samples), and between manufacturer. Because of the design of the data collection approach, it is also possible to explore whether glass manufactured within the same day, or within the same week is like glass manufactured over a longer period of time in the same manufacturing plant.

It is shown that when using these data combined with the data collected by the proposed algorithm out-performs the interval-based comparison criteria.[1] When applied to data other than the data used to develop the interval-based methods, their performance deteriorates significantly, and result in large numbers of miss-classifications.

Reference(s):

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2. Trejos, T., Koons, R., Weis, P., Becker, S., Berman, T., Dalpe, C., Duecking, M., Buscaglia J., Eckert-Lumsdom, T., Ernst, T., Hanlon, C., Heydon, A., et al. 2013. Forensic analysis of glass by µ-XRF, SN-ICP-MS, LA-ICP-MS, and LA-ICP-OES: evaluation of the performance of different criteria for comparing elemental composition. 2013. *Journal of Analytical and Atomic Spectrometry,* 28:1270-1282.
3. E2330-12 Standard Test Method for Determination of Concentrations of Elements in Glass Samples Using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for Forensic Comparisons. 2012. ASTM International.
4. E2927-16 Standard Test Method for Determination of Trace Elements in Soda-Lime Glass Samples Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry for Forensic Comparisons. 2016. ASTM International.

Glass Evidence, Learning Algorithms, False Positives

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