A141 A Novel Mathematical and Digital Image-Based Approach to Gunshot Residue Pattern Interpretation

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After attending this presentation, attendees will understand how digital analysis and numerical interpretation can be applied to gunshot residue patterns. They will know the process by which the patterns were analyzed and the implications this method may have for crime scene investigations.

This presentation will impact the forensic science community by providing a possible method for mathematical support to a field that is largely dependent on subjective interpretation. It will also present a possible option for interpretation of gunshot residue patterns when the firearm in question is not recovered.

Traditional methods of Gun Shot Residue (GSR) pattern interpretation primarily rely on methods such as trial and error, shot re-creation, and sometimes chemical composition analysis in order to estimate muzzle-to-target distances. Most often in these investigations, the firearm in question must be test fired at different distances in order to create patterns to compare to the evidence. These methods rely on judgment and estimation without statistical or numerical support. In other cases, the actual firearm used in the crime is not even recovered to use for test firing. The goal of this study is to test an alternative method that may not only provide statistical support to a firearm/GSR pattern match, but may also aid in identifying or at least narrowing down possibilities for the gun that was fired.

In this study, a new technique for analyzing GSR patterns was preliminarily tested for its possible application to firearm distance and caliber determinations. Under controlled conditions, four different-caliber firearms were used to create GSR patterns, fired at distances ranging from six inches to sixty inches, onto white targets. These patterns were then digitally photographed and uploaded to the software program ImageJ, a program developed by the National Institute of Health that is used in photo analysis for various scientific applications. The photograph of each GSR pattern was analyzed in ImageJ by calculating the average gray value of different areas of the pattern, starting with a one-centimeter-square area directly surrounding the bullet hole (deemed “center” of the pattern) and progressing outwards in concentric squares to the edge of the target containing the pattern (up to 20 centimeters squared). These gray values were compared to the gray scale that was created in each picture using white and black reference squares photographed next to each pattern. The reference squares used were consistent across all photographs, but the gray reference scale was recalculated for each individual photograph in order to take into account lighting differences, a problem that would be very likely to occur in actual crime scene work. The result of these comparisons produced a “relative grayness” output value that could be translated into a mathematical measure of how much GSR was present in each measured region versus the amount of white space left untouched.

Several results were obtained from these initial studies. One such result is that there was a certain distance for each caliber at which there was not enough GSR residue that reached the target for it to produce any data using this analysis method; however, at the closer distances, preliminary analysis of the targets showed a clear trend of variation between the relative grayness gradient of GSR patterns at different distances for the same firearm. Although there was not enough data at this early stage to produce definitive statistics, using the limited samples, there appeared to be a variance of anywhere from one to three standard deviations in some of the sequential distances tested with the same firearm. Additionally, each pattern was treated with either basic hairspray, Rust-Oleum® fixative, or no fixative, and there did not appear to be any significant difference in the stability of the pattern between the three methods.

This work has shown that this method of analysis has potential for application in real-case scenarios involving GSR patterns at close ranges. Information from further studies on this method may allow for this digital image-based process to introduce statistics and analytical methods to GSR pattern interpretation, both of which are virtually absent in present techniques.

GSR Pattern, Digital Picture Analysis, Firearm

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