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Quantitative Measures for Footwear Impression Comparisons

Although research has produced many similarity metrics and scores for quantifying pattern comparisons, pattern evidence disciplines have long had difficulty in applying their methods to casework so that it withstands scientific scrutiny. This NIJ-supported project by the National Institute of Standards and Technology shifts the focus from the question "What is the weight of evidence?" to "What relevant information is available to help assess the weight of evidence?" This project viewed this shift in focus as a significant advance for both the footwear impression discipline and the field of pattern evidence. The project's goal is to develop an end-to-end system called Footwear Impression Comparison System (FICS). This system is based on a workflow that reduces the potential for bias by eliminating side-by-side human evaluation of the questioned impression and test impressions, parallels the analytic sequence examiners already follow, and provides quantitative support for examiner findings in harmony with the Scientific Working Group for Shoeprint and Tire Tread Evidence (SWGTREAD) conclusion scale. The first version of this end-to-end workflow was made into a proof-of-concept graphical user interface application, which is described in this report. Another paper details subsequent work to replace each component of the initial version, focusing on performance and casework utility. This report advises that "successfully completing the long-term research would be a transformative landmark in pattern evidence evaluation."

A Metrology Foundation for 3D Ballistic Imaging

The two key research components of this project by the National Institute of Standards and Technology are 1) the development of prototype physical reference artifacts for key metrological characteristics of 3D surface topography microscopes and 2) providing guidance on how to implement a quality assurance system to monitor and ensure the quality of topography data acquired for firearm and toolmark (FATM) analysis. The 2-year project began with a landscape survey to assess the state-of-the-art of 3D surface topography instruments. Then major commercial vendors were identified that offered instruments capable of being used in FATM analysis. This effort addressed both general-purpose optical surface topography microscopes and systems designed for FATM examination. Next, various documentary standards were reviewed that offer guidance to practitioners on implementing these types of technology. The project then conducted a survey of commercial physical reference artifacts available for performance evaluation, calibration, and quality control of 3D surface topography measurement instruments and methods. The research conducted in this project provides key building blocks for establishing a strong foundation for metrology needed in the effective implementation of 3D optical surface topography methodologies in the FATM forensic discipline.

U.S. National Footwear Database System Feasibility Study

Through an inter-agency agreement with NIJ, the FBI's Laboratory Division (FBI Laboratory) completed a comprehensive, 3-year study known as the National Footwear Database Evaluation. The purpose of this study was to determine the feasibility of developing and implementing a national footwear database (NFD) system for U.S. law enforcement to generate criminal intelligence using footwear evidence and information. A second objective was to determine if an NFD could serve as a tool to forensic science researchers by providing an essential source of footwear data. The results of the FBI Laboratory's study are summarized in five conclusions and three recommendations. The authors of this report determined that the U.S. is not ready to implement a national footwear database system today. However, through

acting on the recommendations and addressing the findings reported, it is possible that the U.S. law enforcement community can transition the outcomes of this evaluation into practice and implement regional footwear intelligence programs (pilots) that will set the stage for a national program in the future. It is possible that future operational footwear databases could provide a source of data for researchers, but the extent to which the data can transfer from operations to research may be limited given privacy concerns and law enforcement sensitivities.

Evaluation of the Routine Use of CT Scanning to Supplant or Supplement Autopsy in a High-Volume Medical Examiner's Office

This NIJ-funded study by the University of New Mexico Health Sciences Center had the primary goal to evaluate the integration of post-mortem computed tomography (PMCT) scanning into the practice of death investigations based on current practices of the New Mexico Office of the Medical Investigator, which includes routine scanning of about 90 percent of decedents to aid in case triage, with image interpretation performed primarily by forensic pathologists. The first phase of the three-phase study evaluated the PMCT image interpretation performance of forensic pathologists for identifying injuries or disease in four types of fatalities in 200 cases: blunt force injury, firearm injury, pediatric trauma, and drug poisoning. Phase 2 evaluated how PMCT imaging was used by forensic pathologists in daily practice and how PMCT impacted their investigations regarding case management, workflow, and resource use. Phase 3 evaluated the effectiveness of integrating PMCT into routine investigations by retrospectively auditing 10 percent of Phase 2 cases. Over 5 years of incorporating PMCT into daily practice, the New Mexico Office of the Medical Investigator has slightly decreased the number of full autopsies, even as the total number of cases reported has increased. This was largely due to the impact of PMCT. Minor unrecognized or undocumented PMCT findings occurred in 95 percent of cases overall, with little difference in the four case categories. The overall conclusion is that pathologists reliably interpreted PMCT scans, avoided major errors, and accurately certified death in most cases. The data suggest that radiology consultation (RC) may reduce major errors, although the statistical significance of RC efficacy could not be determined from this study due to the few cases that used RC.

Postmortem Interval Determination from Bone: A Metabolomics and Lipidomics Approach

This NIJ-funded study by Lincoln Memorial University involved identifying lipid candidates in bone marrow that survived initial soft tissue decomposition processes and were retained for long-term postmortem intervals (PMI). This study is distinctive in its attempt to use quantitative methods to trace the molecular degradation of lipid compounds using high resolution mass spectrometry. The broad goal of this project was to expand lipid data on postmortem intervals of less than 1 year to approximately 30 years since death. Bone biopsy samples of fresh and skeletal donors with varying postmortem intervals (approximately 1-30 years) were subjected to high resolution mass spectrometry to identify preserved lipid biomolecules in bone. The degradation of the identified compounds was tracked for 24 months using relative quantitation methods. Bone biopsies were performed at the sites of medial caicaneus, proximal tibia, and vertebral body (fourth lumbar). The experimental sample and the cross-sectional sample are described, and the findings from the experimental and cross-sectional studies are reported. They indicate that the PMI between 0 and 3 months is the critical period for degradation of bone phosphatidyicholines and that these compounds are preserved in bone at low levels for decades. Although this study established the linear degradation of several phosphatidylcholines housed in trabecular bone, the next step will be to investigate the 0-3-month time interval in more detail. It is also

suggested that this analytical approach establish and use an absolute rather than relative quantitation method. This facilitates the establishment of a database between various laboratories.

Development of Matrix Matched Quality Control Materials and Sample Preparation Techniques for the Analysis of Marijuana Infused Products and their Application to Edible Testing

This NIJ-funded research project from Virginia Commonwealth University had the goal of developing matrix-matched quality-control materials and sample-preparation techniques for the analysis of marijuana-infused products and their application to edible testing. The legalization of marijuana in the United States for both medicinal and recreational use has increased in the past few years. Marijuana is classified as a Schedule 1 substance by the U.S. Drug Enforcement Administration. The U.S. Food and Drug Administration (FDA) does not regulate nor enforce manufacturing restrictions on formulations of THC as Marinol and cannabidiol (CBD) as Epidiolex, which have limited approved therapeutic uses. In 2018, the Agriculture Improvement Act (Farm Bill) legalized hemp; however, this legislation and the approved pharmaceutical preparations do not address the formulation of beverages, nor do they address the standardization of methods for potency analysis of cannabinoids in edibles and beverages. Forensic laboratories are receiving an increasing workload of cannabinoid products for analysis. The analysis of these products may be questioned since there are limited published methods for analysis and no known publications of storage and stability of cannabinoids in various “medible” and beverage matrices. In addressing these issues, the current project had three major goals. First, it sought to develop and optimize sample preparation techniques for the analysis of cannabinoids in edible matices (brownies, chocolate, and gummies), using a previously optimized ultrahigh pressure liquid chromatography system with tandem mass spectrometer detector. A second goal was to develop quality-control materials for three common edible matrices to determine cannabinoid stability in these materials. Third, it sought to determine cannabinoid stability in quality-control materials under storage and time variables. The research design, methods, and analytical and data analysis techniques are described, and results are reported.