National Institute of Justice

Office of Investigative and Forensic Sciences

FY 2009-10: Forensic Science Discretionary Awards made by the National Institute of Justice's (NIJ) Forensic Science Research and Development Program

Questions and/or comments should be submitted to:
Forensic.Research@ojp.usdoj.gov

Introduction

This document contains the submitted abstracts of all FY 2009 and FY 2010 discretionary awards that were made by the National Institute of Justice's (NIJ) Forensic Science R&D Program. This is not an official publication of the U.S. Department of Justice. Findings and conclusions reported in this document are those of the authors and do not necessarily reflect the official position or policies of the U.S. Department of Justice. Products, manufacturers, and organizations discussed in these materials are presented for informational purposes only and do not constitute product approval or endorsement by the U.S. Department of Justice.

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FY 2009 Forensic Science R&D Solicitations and Awards

In FY 2009, there were a total of four (4) research and development solicitations released by NIJ on behalf of the General Forensics R&D, Fundamental Forensic Science Research, and Forensic DNA R&D Programs. These include:

- "Research and Development on Impression Evidence"
- "Research and Development in the Forensic Analysis of Trace Evidence"
- "Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines"
- "Forensic DNA Research and Development"

Of these four (4) solicitations, a total of forty-five (45) awards were made by the NIJ to the amount of $19,732,737.

#1. Research and Development on Impression Evidence

Posting Date: November 13, 2008

Closing Date: December 29, 2008

Awards Made: 6

With this solicitation, NIJ sought proposals for research and development to enhance crime laboratories' ability to identify, characterize, capture, visualize, and preserve impression evidence. Specifically, this solicitation focused on:

- Tools and technologies that will allow faster, more widely applicable, more rugged, less costly, or less labor-intensive identification, collection, preservation, and analysis of impression evidence at the crime scene or crime laboratory.
- Tools that provide a quantitative measure or statistical evaluation of forensic comparisons.
- The effect of time and environmental factors on impression evidence.
- The unique forensic characteristics found in impression evidence.

In addition, NIJ sought proposals for an innovative and cost-effective approach to capturing and comparing ballistic images for potential use to improve the National Integrated Ballistics Information Network (NIBIN).

FY 2009 Impression Evidence R&D Awards

Grant Number	Grantee	Title	Page #
2009-DN-BX-K257	The Regents of the University of California	A Proposal to Develop a Computer Program to Improve the National Integrated Ballistics Information Network	Pg. 6
2009-DN-BX-K168	The Regents of the University of California	Consecutive and Random Manufactured Semi-Automatic Pistol Breech Face and Fired Cartridge Case Evaluations	Pg. 7
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2009-DN-BX-K208	The Research Foundation of State University of New York	Quantitative Measures in Support of Latent Print Comparison	Pg. 10
2009-DN-BX-K041	Research Foundation of CUNY c/o John Jay College	Application of Machine Learning to Toolmarks: Statistically Based Methods for Impression Pattern Comparisons	Pg. 11
2009-DN-BX-K204	Pace University	Use of Magneto-Rheological Fluids for Collecting, Preserving, and Analyzing Toolmark and Impression Evidence	Pg. 12

2009-DN-BX-K257

The Regents of the University of California

"A Proposal to Develop a Computer Program to Improve the National Integrated Ballistics Information Network"

Principal Investigator:

Dr. David Howitt
dghowitt@ucdavis.edu

Funding Amount:

$1,398,930 for 3 years

Abstract:

What is proposed here is a program to create a searchable desktop computer database for 10,000 bullets based upon the documentation of the positions of striae across the land and groove impressions to an accuracy of 20 microns using a confocal microscope. These micron distances of the maxima and minima in the profile heights will then be stored as integer strings which will be the basis for the computer search comparisons.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2009-DN-BX-K168

The Regents of the University of California

"Consecutive and Random Manufactured Semi-Automatic Pistol Breech Face and Fired Cartridge Case Evaluations"

Principal Investigator:

Dr. David Howitt
dghowitt@ucdavis.edu

Funding Amount:

$703,091 for 2 years

Abstract:

We propose to evaluate the impression markings on cartridge cases fired from semi-automatic pistols to determine to what extent these markings can be used to match with a particular firearm and whether they can be interpreted in the same way as the random striations on fired bullets. Using optical and confocal microscopy techniques and a specific set of firearms, some that are as similar to each other as possible, we plan to identify and quantify the surface of the cartridge cases in terms of class, subclass and random characteristics. Because one can interpret any association between random features as a numerical probability, we shall also develop procedures for the examiners to determine the quantitative significance of the comparisons they make in terms of the extent of the individual regions of correspondence from the breech face and firing pin that would be expected to occur by pure chance.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2009-DN-BX-K262

SED Technology LLC

"Improve the NIBIN system by Providing Examiners a Capability to Match Infrared Images of Firing Pin Impressions and Deformed Bullets as well as Accurate Large Database Searches"

Principal Investigator:

Mr. Stanley Derr
sderr@sedllc.com

Funding Amount:

$729,000 for 2 years

Abstract:

The Goal of the proposed SED Technology LLC (SED) grant is to develop tools for test and evaluation of infrared imaging to upgrade NIBIN performance. SED recently completed an Office of Justice Program cooperative agreement that investigated potential benefits of infrared imaging over visible light imaging for identification of toolmark evidence. Image collections and comparisons were performed with the use of the previously developed MIKOS Forensic Toolmark Workstation (MTW) with FlashCorrelation® matching technology. Jack Dillon validated the advantages of infrared imaging for analysis of cartridge cases and toolsmarks. Key benefits are the elimination of: lighting-induced artifacts and need for controlled lighting. SED proposes to expand on prior research by addressing three inter-related Objectives:

First objective is to develop capability and procedures to image and compare details of firing pin impressions. During the previous grant we demonstrated that IR can be used to image the depth of the firing pin impression that cannot be seen using visible light cameras. It is our hypothesis that these marks will be persistent and remain essentially unchanged with multiple firings from the same firearm. To validate this, seven different firearms will be obtained and fired 1,000 times. After each 100 firings, the cartridge case will be tagged and imaged. Changes in the imagery will be noted and described for each firearm. If significant changes are seen, additional casings will be imaged. An attempt will be made to quantify the degree of change as a function of firing number for each firearm.

Second objective is to extend infrared imaging to bullets. Methods will be developed and demonstrated for collecting infrared imagery of water tank test fired bullets, and deformed bullets. Sequences of image frames will be combined into an integrated image. During the previous grant Dr. Prokoski demonstrated a "cut line" technique using infrared imaging that extracted a one pixel wide swipe of screwdriver scrapes on lead test strips, expanded it into a bar code for easy visualization, and compared the resulting barcodes to identify toolsmarks made by other persons using the same tool. A similar approach will be attempted with the integrated images collected from test fired bullets. Both the image integration and comparison of extracted "cut lines" are technically challenging initiatives that may not

be fully successful under the budget and schedule of this project. However, we expect to make substantial progress toward both. The deformed bullets will be obtained by collecting bullets fired during the casings collection activities described above. Firings will be into a water tank and into wood targets that deform the bullets.

Third related objective is to develop a larger collection of infrared images of cartridge cases. During the previous grant we used the MTW and its FlashCorrelation® matching technology to image and accurately match infrared images of casing pairs fired from more than 100 Glocks. During this grant, we plan to build a database of 1,000 to 10,000 images that can be used to investigate accuracy rates.

Mr. John (Jack) Dillon, a world class expert in firearms and toolmarks identification, will be the team leader with Dr. Jim Hamby and Dr. Francine Prokoski being key technical support. Mr. Dillon and Dr. Hamby will prepare written instructions for examiners, on how to use this technology. Results will be disseminated through meetings with current examiners, the SWGGUN working group, presentations and booths at AFTE and IAI conferences, and articles in selected journals. We are proposing a 20 month period of performance and a $729,000 estimated cost.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2009-DN-BX-K208

The Research Foundation of State University of New York

"Quantitative Measures in Support of Latent Print Comparison"

Principal Investigator:

Dr. Sargur Srihari
srihari@cedar.buffalo.edu

Funding Amount:

$498,784 for 2 years

Abstract:

While impressions of friction ridges have long been useful in forensic identification, there continues to be a need for quantitative measures. Towards this goal this research will have three areas: (i) determination of probability distributions of fingerprint features, (ii) reliability of the process (as measured by uniqueness and permanence of the fingerprints), and (iii) a formalization of the decision process to incorporate cost and other criteria. Each of these studies will be aided by a newly created database of high-quality friction ridge impressions of twins collected by the International Association for Identification (IAI) in August 2007 and an earlier database collected in 2003. In conjunction with an earlier database collected in 2003, these databases offer an unprecedented opportunity for a cross-sectional study measuring individuality and a longitudinal study measuring permanence. The databases will be supplemented with other friction-ridge databases such as those from NIST for calculating parameters of probability distributions. A real-time method of computing the probability of random correspondence (PRC) of fingerprints will be developed so that a minutiae pattern can be submitted to a website which returns the PRC value. Likelihood probability methods used in DNA will be studied for their appropriateness for use in the latent print domain. A cost model that assigns specific values to errors of decisions (identification, exclusion and inconclusiveness) will be explored to determine their value to expressing decisions by the latent print examiner. The project will ultimately strengthen the science of friction ridge analysis an its use in the criminal justice system

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2009-DN-BX-K041

Research Foundation of CUNY c/o John Jay College

"Application of Machine Learning to Toolmarks: Statistically Based Methods for Impression Pattern Comparisons"

Principal Investigator:

Dr. Nicholas Petraco
npetraco@jjay.cuny.edu

Funding Amount:

$704,189 for 1 year

Abstract:

Over the last several decades forensic toolmark and ballistic examiners have struggled with the fact that there is no accepted methodology to generate numerical proof that independently corroborates morphological conclusions in questioned toolmark, firearm and other forensic impression examinations. Here we propose to develop standardized methodologies to study and critically evaluate impression evidence. Point cloud data will be collected using high resolution 3D laser scanning and stored in a large database. The data will then be examined with multiple multivariate statistical methods in order to quantify what it means for two or more impression patterns to match. The particular mathematical techniques we will examine for impression pattern comparisons are principal component analysis, partial least squares, independent component analysis, neural networks, kernel support vector machines, cluster analysis and Bayesian decision theory with discriminant analysis.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2009-DN-BX-K204

Pace University

“Use of Magneto-Rheological Fluids for Collecting, Preserving, and Analyzing Toolmark and Impression Evidence”

Principal Investigator:

Dr. Demosthenes Athanasopoulos
dathanasopoulos@pace.edu

Funding Amount:

$186,950 for 3 years

Abstract:

The collection and preservation of tool mark and impression evidence is an important part of the field of criminalistics. The ability to discern class and individual characteristics and use these to either identify or exclude an item as a possible match is a powerful tool in a criminalist's arsenal. The ability, then, of a casting agent to resolve the fine scale details of a tool mark or impression become of the utmost importance. An innovative approach to this problem is utilizing aqueous- and hydrocarbon-based Magneto-Rheological fluids as an agent to capture impression in situ. These materials are fluid under most conditions, but form a solid when a magnetic field is applied to them and can be used in lieu of dental stone or mikrosil for collecting impression evidence. By varying the size of the magnetic particles suspended within the fluid, the resolving capabilities of the MR fluids as a casting agent can be fine-tuned to suit the job at hand.

The Magneto-Rheological fluid's efficacy as a casting agent will be the focus of this study, on both a range of impression types and on a variety of substrates, along with an analysis of the amount of detail retained by the MR fluid as opposed to conventional methods of impression recovery. Also to be explored will be the benefits of using aqueous versus hydrocarbon-based MR fluids for different substrates. Lastly to be reviewed will be methods to preserve the cast, including using digital imaging to capture a three dimensional map of the surface of the MR cast, which can then be used to fabricate a replica; and using traditional casting materials to make copies of the original impression using the MR fluid cast as a mold. In addition, provisions will be made for the casting of impressions on non-horizontal surfaces using magnetic frames to hold the MR fluid against the surface to be examined.

Our preliminary experiments have shown that the MR fluid is able to resolve and maintain a level of detail capable of identifying class and individual characteristics, and with more effort toward the goal of optimizing the fluid's capabilities, MR fluids can become a valuable tool in the field of tool mark and impression examination.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

#2. Research and Development in the Forensic Analysis of Trace Evidence

Posting Date: November 13, 2008

Closing Date: December 29, 2008

Awards Made: 5

With this solicitation, NIJ sought proposals for research and development in trace evidence investigation that would improve the crime scene investigator's ability to locate and identify trace evidence and enhance the ability of crime laboratories to analyze trace evidence. Specifically, this solicitation focused on:

- Novel methods to detect, collect, and preserve trace evidence from crime scenes and other evidentiary items.
- Development of analytical techniques that will improve the discriminatory power of trace evidence beyond current practice.
- Research on specificity/importance of microscopic comparisons of hair as compared with other techniques.
- Novel approaches and enhancement of current approaches to interpret data derived from trace evidence, including assessment of the significance of association.

FY 2009 Trace Evidence R&D Awards

Grant Number	Grantee	Title	Page #
2009-DN-BX-K251	The Florida International University Board of Trustees	Rapid Screening and Confirmation of Organic GSR using Electrospray Mass Spectrometry	Pg. 16
2009-DN-BX-K252	The Florida International University Board of Trustees	Significance of Elemental Analysis from Trace Evidence	Pg. 17
2009-DN-BX-K216	NC State University	Method Development and Validation of Comparative Finished Fiber Analysis Using Nano-Sampling Cryomicrotomy and Time-of-Flight Secondary Ion Mass Spectrometry	Pg. 19
2009-DN-BX-K199	University of Nebraska	Developing a high throughput protocol for using soil molecular biology as trace evidence	Pg. 21
2009-DN-R-112	Ames Laboratory	Improvements to Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) for Quantitative Forensic Analysis using a Short Pulse [100 Femtosecond] Ultraviolet Laser	Pg. 23

2009-DN-BX-K251

The Florida International University Board of Trustees

"Rapid Screening and Confirmation of Organic GSR using Electrospray Mass Spectrometry"

Principal Investigator:

Dr. Bruce McCord
mccordb@fiu.edu

Funding Amount:

$291,340 for 2 years

Abstract:

The goal of this proposal is to develop a rapid method to screen and confirm the presence of organic gunshot residue using electrospray mass spectrometry. Currently gunshot residue is analyzed for the elements lead, barium, and antimony using SEM/EDX to do elemental analysis or, less commonly, using atomic spectroscopy techniques such as graphite furnace atomic absorption. These methods, while useful, ignore another area of potential evidence: the organic compounds released during the firing of a weapon. As manufacturers continue to bring new, lead-free primer formulations to the market it is imperative to develop alternate techniques for gunshot residue analysis. While it is possible to use GC/MS to detect many of these compounds, the technique can perform poorly when asked to detect critical components of primer residue such as nitrodiphenylamines and nitroglycerine due to the high temperatures in the injector and column. Instead, we propose an alternative approach using electrospray infusion for sample screening. The procedure is extremely fast, involving simply spraying an organic extract into the mass spectrometer and monitoring specific ions. For enhanced sensitivity we will use a time-of-flight mass spectrometer; however, ion trap systems with MS/MS capability could also be used. Following a positive response, the sample can be quickly screened using a newly developed procedure combining a short high-resolution microHPLC or CEC column with the electrospray system. The development of this procedure will permit fast screening of organic gunshot residue by any forensic laboratory with access to an LC/MS system.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2009-DN-BX-K252

The Florida International University Board of Trustees

"Significance of Elemental Analysis from Trace Evidence"

Principal Investigator:

Dr. Jose Almirall
almirall@fiu.edu

Funding Amount:

$366,322 for 2 years

Abstract:

Trace evidence recovered from crime scenes can provide useful information to aid an investigation that leads to identifying a suspect and can also provide strong associations between the suspect and a crime event. The proposed research is divided into two main efforts. For the first part, the acquisition of elemental data from common trace evidence materials found at crime scenes (paint, glass, soils) using standardized methods and certified reference materials will provide the scientific validity of applying methods for elemental analysis used to interrogate these materials for probative information. The proposed research will demonstrate that the quality of the chemical information derived from a variety of analytical methods, if conducted properly using standardized parameters, is extremely good, regardless of the method used (LA-ICP-MS, μXRF or LIBS). Many studies have been conducted over the last three decades illustrating the discrimination power of elemental analysis for these types of evidence. More recently, research in the US, Germany and Australia has provided further refinement of the analytical methodology, particularly for the application of LA-ICP-MS, which is generally accepted in geochemistry and analytical chemistry for quantitative analysis of materials. The technique of μXRF is preferred in the US forensic laboratory with approximately 40 forensic laboratories employing the technique currently (from a total of 85 and 66 laboratories reporting conducting elemental analysis in 2007 and 2008 CTS proficiency tests in glass analysis, respectively) but there is less standardization of the μXRF technique. There is also growing evidence that the emerging analytical technique of Laser Induced Breakdown Spectroscopy (LIBS) can produce similar information to both μXRF and LA-ICP-MS for the analysis of materials such as glass and paint while also provide important advantages over these techniques in the form of ease of use and speed of analysis as compared to μXRF and LA-ICP-MS, and improved capability to analyze very small and irregularly shaped fragments (as μXRF does not perform well for these commonly encountered samples). The first part of the proposed effort will also incorporate information available in existing glass databases from population surveys (primarily the TSWG sponsored glass database created by FIU using ICP-MS and the FBI historical casework data using ICP-OES) to enhance the understanding of the selection of a match criteria (determination of match/no match based on objective and statistically valid reasoning) for univariate and multivariate comparisons of data. The new forensic application of LA-ICP-OES will be evaluated for the forensic analysis of glass

evidence for the first time. While there is much historical information on solution (digestion) analysis of glass using ICP-OES analysis, there are few reports in the literature coupling the advantages of solid sampling with the more accessible ICP-OES technique (as compared to ICP-MS) for forensic analysis. Furthermore, the types of data (spectroscopic emissions) obtained from ICP-OES are very similar to the data obtained from the emerging and even more accessible LIBS technique. It is anticipated that the LA-ICP-OES data generated through this study will complement both the LA-ICP-MS data already obtained, corroborate the existing solution ICP-OES data and provide a better understanding of the LIBS data. The second part of the proposed project will aim to utilize the collective experience and knowledge base within the trace evidence community that routinely conducts elemental analysis of materials (glass, paint and soils) to address the gaps in understanding of the significance of trace elemental profile matches, when they are found. Recent surveys of experienced trace evidence examiners reveal that there is a wide range of language used to describe the meaning of an elemental profile "match" in reporting of results and in testimony. The proposed study will engage approximately 20 experienced trace examiners that will participate in round-robin and discussion exercises over the course of two years with an aim to agree on a common and consensus language that can be applied to describe the meaning of a trace elemental profile match for common trace evidence.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2009-DN-BX-K216

NC State University

"Method Development and Validation of Comparative Finished Fiber Analysis using Nano-Sampling Cryomicrotomy and Time-of-Flight Secondary Ion Mass Spectrometry"

Principal Investigator:

Dr. David Hinks
david_hinks@ncsu.edu

Funding Amount:

$619,140 for 2 years

Abstract:

A primary goal of a major new Center for Forensic Sciences under development at North Carolina State University is to address directly many of the recommendations of the National Academies Report, Strengthening Forensic Science in the United States: A Path Forward, that was published February 18, 2009 [1, 2]. Several research thrusts will be pursued, including a focus on the development of next generation trace evidence methodologies with improved capability, repeatability, reproducibility and statistical confidence, and the development of comprehensive databases. In addition, recent discussions with our collaborators in the Trace Evidence Unit at the North Carolina State Bureau of Investigation (SBI), at the Federal Bureau of Investigation (FBI) Laboratory, and data obtained from a real-time survey completed by law enforcement attendees at the 1st NCSU Forensic Sciences Symposium on December 5, 2008 (http://www.tx.ncsu.edu/forensics/symposium; click agenda; username: 'symposium', password: 'lelearn2008') led us to focus on these research priorities: Quantification of trace evidence analysis, database development and searching, and improvement in CSI methodology. This proposal is part 1 of a multi-part program. It will focus on method development to establish more rigorous standard methods of analysis for finished fibers with only nano- or micro-level destruction of the fiber, thereby essentially having an insignificant negative impact on the preservation of evidence. This will be achieved via sub-micron level sample removal using cryomicrotomy followed by Time-Of-Flight Secondary Ion Mass Spectrometry (TOF SIMS) analysis of the surface and cross-section of pre-dyed fibers. TOF SIMS was recently brought on-line at NCSU (www.ncsu.edu/aif/). The use of Focused Ion Beam (FIB) for nanoscale sampling for subsequent TOF SIMS analysis will also be investigated as a possible alternative method of sample preparation. In this work we aim to deliver an unprecedented, reliable and high impact methodology that will become a forensic standard for finished fiber analysis. Key to the method development will be validation of results of the nano-surface and nano-penetration TOF SIMS approach by comparison to a microextraction-based liquid chromatography method, based on a new LC TOF, which also was recently brought on-line at NCSU (www.ncsu.edu/chemistry/msf/instrumentation.html). Part two of the work (not part of this proposal) will employ the new optimized forensic standard method in the development of a living, searchable National Information Exchange Model (NIEM) compliant [3]

dyed fiber database that may include LC chromatograms, UV VIS DAD spectra, microspectrophotometry spectra, Liquid Chromatography LC TOF mass spectra, and TOF SIMS mass spectra as part of a comprehensive search tool. The new finished fiber TOF SIMS analysis approach may be rapidly extendible to the development of other living and searchable databases (e.g. gun shot residue, plastics, cosmetics, printing and document analysis, paint, glass, composites, rope, and metal surface analysis) so that the entire field of materials-based trace evidence analysis can be advanced.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2009-DN-BX-K199

University of Nebraska

"Developing a High Throughput Protocol for using Soil Molecular Biology as Trace Evidence"

Principal Investigator:

Dr. David Carter
dcarter2@unl.edu

Funding Amount:

$142,475 for 2.5 years

Abstract:

Soils have a long history as trace evidence. This use is typically based on their chemical and/or physical properties. Recent research has shown that the biochemical components of soils can be used as trace evidence. However, detailed research is required to establish this use and meet admissibility requirements. One of the most pressing issues is the effect of storage and handling on the biochemical profiles of soils evidence. The central null hypothesis of the proposed work is that storage will not affect soil biochemical profiles. By testing this hypothesis we can answer two fundamental questions: (1) Can soil handling and storage affect the biochemical profile of soils and (2) Does the biochemical profile of soil collected at the time of the investigation match the biochemical profile of soil at the time of the crime? Because time and resources are limited in all investigations, we propose to develop methods for the high throughput analyses of soil sample bacterial populations by nucleotide sequence and lipid profiles. The molecular signature of soil bacteria will be captured by quantitative polymerase chain reaction (qPCR) and capillary electrophoresis-single strand conformation polymorphism (CE-SSCP). These methods will provide a snapshot of bacterial diversity in soil. Fatty acid methyl ester fingerprinting (FAMEs) will quantify changes in soil microbial community composition in response to storage treatment. The lipid profile provides an independent quantitative assessment of microbial community composition.

It is possible that nucleotide sequences and lipid profiles are sensitive to different storage methods. Standard soil chemical analyses (e.g. electrical conductivity, cation exchange content, pH) will serve as non-biological controls. These analyses will be conducted on three contrasting soils within Nebraska. The biochemical profiles of soils will be analyzed immediately following collection and following six soil storage treatments: cooling at 4 °C, freezing at -20 °C, freezing at -80 °C, freeze drying, air drying at room temperature, and oven drying at 105 °C (for 48 hours then stored in polypropylene at room temperature). After a minimum of seven days the collection sites will be revisited, fresh soils will be collected and analyzed immediately. This mimics comparison of soils at the time of the crime, soils following storage, and soils at the time of the investigation. Results from this project will support recommended protocols for the storage and analysis of soil biochemical profiles. These protocols can

guide investigative agencies during investigation. In addition the protocols can inform a soils expert on the most applicable and accurate analysis when soil has been stored in one of many ways.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2009-DN-R-112

Ames Laboratory

"Improvements to Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) for Quantitative Forensic Analysis using a Short Pulse [100 Femtosecond] Ultraviolet Laser"

Principal Investigator:

Dr. Robert Samuel Houk
rshouk@iastate.edu

Funding Amount:

$200,000 for a 1 year proof-of-concept study

Abstract:

Laser ablation inductively coupled plasma – mass spectrometry (LA-ICP-MS) is a non-destructive method for trace elemental analysis of solids. Trace element composition can sometimes be useful in forensic applications for matching or attribution studies, in which a material recovered from a crime scene is compared to one from a suspect. This two-year project will utilize the latest development in LA technology: a new short pulse (~100 fs) ultraviolet (266 nm) laser available in the PIs lab. Such a laser is believed to provide particulates from the sample that are closer to its real elemental composition and that are much better atomized and ionized when they travel through the ICP. The result is more accurate elemental identification and better quantification with less need for closely matched solid standard materials. When combined with our magnetic sector ICP-MS instrument, the result is very high sensitivity (i.e., sub-ppb levels can be measured) and selectivity for trace elements. These improved analytical capabilities should extend the scope of application of trace element evidence to different materials (e.g., glass panes, metals, plastics, tapes) of forensic interest.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

#3. Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines

Posting Date: May 6, 2009

Closing Date: June 22, 2009

Awards Made: 16

With this solicitation, NIJ sought qualified applicants to conduct research to improve the understanding of the accuracy, reliability, and measurement validity in the forensic science disciplines. Although not discipline-specific, this solicitation's intended focus was primarily on the forensic disciplines that are considered to be semi- and highly-qualitative in nature.

The individual discipline categories that were targeted by this solicitation include:

1. Firearms and Toolmark Identification
2. Questioned Documents
3. Trace Evidence
4. Fire Debris Analysis and Arson Scene Investigations
5. Latent Print Examination
6. Blood Pattern Analysis
7. Digital Evidence

The most competitive proposals addressed a combination of the following specific research topics:

- Strengths and limitations of each procedure
- Sources of bias and variation
- Quantification of uncertainties created by these sources
- Measures of performance
- Procedural steps in the process of analyzing forensic evidence
- Methods to continuously monitor and improve the steps in the forensic evidence analysis process

FY 2009 Fundamental Forensic Science Research Awards

Grant Number	Grantee	Title	Page #
2009-DN-BX-K230	Miami Dade County	Repeatability and Uniqueness of Striations/Impressions in Fired Cartridge Casings Fired in 10 Consecutively Manufactured Slides	Pg. 27
2009-DN-BX-K224	Complete Consultants Worldwide, LLC	Quantified Assessment of AFIS Contextual Information on Accuracy and Reliability of Subsequent Examiner Conclusions	Pg. 29
2009-DN-BX-K235	University of California-Davis	Statistical Evaluation of Torn Duct Tape	Pg. 31
2009-DN-BX-K237	University of Central Florida	Experimental Study of the Validity and Reliability of Digital Forensics Tools	Pg. 32
2009-DN-BX-K238	NY City Office of Chief Medical Examiner (OCME)	Microscopic Analysis of Sharp Force Trauma in Bone and Cartilage	Pg. 34
2009-DN-BX-K231	University of Notre Dame du Lac	Face Annotation at the Macro-scale and the Micro-scale: Tools, Techniques, and Applications in Forensic Identification	Pg. 35
2009-DN-BX-K229	Virginia Polytechnic Institute and State University	Establishing the Quantitative Basis for Sufficiency: Thresholds and Metrics for Friction Ridge Pattern Detail Quality and the Foundation for a Standard	Pg. 37
2009-DN-BX-K228	Western Oregon University	Application of Spatial Statistics to Latent Print Identifications: Towards Improved Forensic Science Methodologies	Pg. 39
2009-DN-BX-K236	Intelligent Automation, Inc	Development of Synthetically Generated LEA Signatures to Generalize Probability of False Positive Identification Estimates	Pg. 41
2009-DN-BX-K232	Hughes Associates, Inc	Forensic Analysis of Ignitable Liquid Fuel Fires in Buildings	Pg. 43

Grant Number	Grantee	Title	Page #
2009-DN-BX-K225	The Regents of the University of California	Error Rates for Latent Fingerprinting as a Function of Visual Complexity and Cognitive Difficulty	Pg. 44
2009-DN-BX-K226	Indiana University	The Information Content of Friction Ridge Impressions as Revealed by Human Experts	Pg. 46
2009-DN-BX-K227	University of Central Florida	Statistical Assessment of the Probability of Correct Identification of Ignitable Liquids in Fire Debris Analysis	Pg. 47
2009-DN-BX-K233	Virginia Polytechnic Institute and State University	Fundamental Research to Improve the Understanding of the Accuracy, Reliability, and Validity of Using the ENF Criterion for the Forensic Authentication of Digital Recordings	Pg. 48
2009-DN-BX-K234	George Mason University	Quantifying the Effects of Database Size and Sample Quality on Measures of Individualization Validity and Accuracy in Forensics	Pg. 50
2009-DN-R-119	Ames Laboratory	Manipulative Virtual Tools for Tool Mark Characterization	Pg. 52

2009-DN-BX-K230

Miami Dade County

"Repeatability and Uniqueness of Striations/Impressions in Fired Cartridge Casings Fired in 10 Consecutively Manufactured Slides"

Principal Investigator:

Dr. Thomas Fadul
tgfadul@mdpd.com

Funding Amount:

$17,127 for 2 years

Abstract:

The Miami-Dade Police Department (MDPD) Crime Laboratory Bureau (CLB) is proposing "The Repeatability and Uniqueness of Striations/Impressions on Fired Cartridge Casings Fired in 10 Consecutively Manufactured Slides" as a project for funding in the amount of $17,126.60 from the Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines Grant Program. The foundation of firearm and tool mark identification is that each firearm/tool produces a signature of identification (striation/impression) that is unique to that firearm/tool, and through the examination of the individual striations/impressions, the signature can be positively identified to the firearm/tool that produced it. The National Academy of Sciences (NAS) Report questioned the repeatability and uniqueness of striations/impressions left on fired evidence as well as the validity and error rate in firearms identification. This study will analyze the repeatability and uniqueness of striations/impressions on fired cartridge cases fired in 10 consecutively manufactured slides by analyzing breech face striations/impressions. One semi-automatic pistol and nine additional slides will be purchased from a leading firearms manufacturer. Consecutively manufactured slides are significant to the study because these slides will be manufactured with the same equipment/tools. Even though these slides are consecutively made, their signatures should be different. Test sets will be assembled which will include test fired casings from each slide, as well as unknowns. Participants will be firearm & tool mark examiners throughout the United States. This research study will provide an error rate for the identification of same gun evidence that will be calculated by an independent statistician from a local academic institution. The results of this study will also provide test documentation of the following two research questions:

1) Will firearm and tool mark examiners be able to identify unknown casings fired through consecutively manufactured slides to the firearms that fired them utilizing individual, unique and repeatable striations/impressions?
2) Will the experience level of firearm and tool mark examiners affect results when examining casings fired through consecutively manufactured slides?

This fundamental research will improve understanding of the accuracy, reliability and validity of the forensic science discipline of firearm and tool mark identification.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K224

Complete Consultants Worldwide, LLC

"Quantified Assessment of AFIS Contextual Information on Accuracy and Reliability of Subsequent Examiner Conclusions"

Principal Investigator:

Mr. Kasey Wertheim
kaseywertheim@aol.com

Funding Amount:

$348,770 for 1 year

Abstract:

Lying at the intersection of science and law, and subject to the scrutiny of both, is fingerprint identification, which has come under fire recently with the National Academy of Sciences report on Forensic Science. A relatively new feature of the latent print identification landscape is the increasing use of Automated Fingerprint Identification Systems (AFIS) over the last decade. When it relates to criminal cases where only partial and distorted latent prints are available, AFIS presents for human examination the most likely candidate fingerprint records that would not easily be found otherwise. AFIS is arguably the most powerful forensic identification tool available to law enforcement today.

While AFIS represent advances in process and productivity, it introduces metadata that may or may not influence the results of the subsequent human expert examination. These are not the only potential biases that may affect latent print examinations. They are, however, factors that have been criticized as being potential sources of bias. They are also subject to being controlled by process and workflow design. With the growing use of AFIS, it is important to use careful scientific studies to provide understanding of how contextual information provided by AFIS may affect the accuracy and reliability of the conclusion reached by the human expert working with AFIS.

This project includes three studies that address the urgent need for a valid and quantified basis for informed decision making about best practices by technology integrators and identification units. Each study uses 160 different latent prints, a total of 480 latents in this project. These latents will be used to generate 2,560 different AFIS candidate lists by manipulating scores, ranking, and length of lists. Overall, the three studies will include a total of 172,800 comparisons done by expert IAI certified latent print examiners.

The scientifically rigorous experimental designs will detect and quantify any potential influences these factors (scores, ranking, quality of print, and length of candidate list) may have on the human experts' perception and cognition that may bias their decision making. The conclusions from these studies will be then translated to practical best practices and proper ways to use AFIS technology so as to maintain its

benefits while reducing any potential vulnerabilities that it may introduce (dependent upon these study results).

Within each study we will use fingerprint impressions of medium and low quality in order to make the results most applicable to potentially vulnerable examiner judgments and to help anticipate the importance of impression quality in further bias studies. Our experimental manipulation may well show that the biases in this study only manifest with lower quality latent print comparisons, which would emphasize the need for the implementation of automated quality metrics into modified workflows.

Studies in this field too often suffer from admitting too many factors or failing to clearly associate results with actual examination. This project is appropriately parsimonious, in that it examines well-defined potential biases that may affect the conclusion, the end product of examination. The focus and scope of this project's design enable us to directly and immediately translate the findings of the scientific study into tangible ways to counter any biases that may occur.

The project team is well suited to carry out this project; it has cross-discipline experiences and expertise that will bring this project to a successful completion. The project team includes, and has a good and healthy balance of, forensic practitioners who understand the real and pragmatic world of fingerprint analysis and use of AFIS, and scientific researchers who have a track record of conducting such studies in the forensic domain and have particular expertise in bias and decision making.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K235

University of California-Davis

"Statistical Evaluation of Torn Duct Tape"

Principal Investigator:

Mr. Fred Tulleners
ftulleners@ucdavis.edu

Funding Amount:

$154,300 for 1.25 years

Abstract:

This study will attempt to obtain statistical inferences on the uniqueness of duct tape that has been torn and on the subsequent attempt to match it to the tear. Duct tape is frequently used in crimes of violence and has a significant evidentiary value when torn ends left at the scene are physically matched to the torn end on a roll of duct tape that may be recovered from a suspect. However, a review of the literature on physical matching illustrates that when the final determination is made, the only statement that exists is that the tape physically matches. There is neither supporting statistical data nor are there any objective criteria as to what constitutes a match or its associated error rate. This study will compare approximately 1,000 duct tape tears and if time permits additional duct tape cuts made by scissors. This proposed study will provide error rates and attempt to develop objective criteria for the physical matching of duct tape samples.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K237

University of Central Florida

"Experimental Study of the Validity and Reliability of Digital Forensics Tools"

Principal Investigator:

Ms. Carrie Whitcomb
whitcomb@mail.ucf.edu

Funding Amount:

$382,000 for 1 year

Abstract:

Digital forensic techniques and tools, as with all other forensic disciplines, must meet basic evidentiary and scientific standards to be allowed as evidence in legal proceedings. In order to be admissible, evidence or opinion derived from scientific or technical activities must come from methods that are proven competencies to be "scientifically valid." Scientifically valid techniques are capable of being proven correct through empirical testing. In practice, this means that the tools and techniques used in digital forensics must be validated, and that crime laboratories, including digital forensic labs, should be accredited or otherwise proven to meet such scientific standards. This task is overwhelming for governmental agencies that lack funding to perform a full-scale validation of all forensics tools. Validation is often left to the individual examiners, who may lack the expertise and resources to conduct a scientific validation.

Our project directly addresses the National Academies' concerns related to measurement validity in the digital evidence domain. As a solution to this problem, researchers from the University of Central Florida, Purdue University, and law enforcement digital forensic experts will conduct studies to identify issues with the reliability and accuracy of the most accepted software and hardware in use by law enforcement forensic examiners. Our research design is based on employing these tools to conduct the common forensic tasks across varying operating system and file system conditions following the NIST Computer Forensics Tool Testing Guidelines. We have selected popular commercial forensic suites as well as some free and open source software for inclusion in our test bed. These tools run under Windows OS, Mac OS X or Linux. Our research design includes the most frequently encountered file systems, and includes several file systems for each of Windows OS, Mac OS X, and Linux distributions. We have also included select hardware write blockers in our research design, as they are crucial to the forensic examiner's ability to duplicate media without changing the original evidence.

We have selected black box testing and comparative analysis as methods for identifying issues with accuracy and reliability of our selected hardware and software. In black-box testing, the software serves essentially as a "black box" and the performance of the application is evaluated against functional requirements. In a digital forensics context, testing is performed using a tool to perform forensics tasks

under various conditions, such as; different file systems, various digital artifacts, different hardware, and various software parameters (switches and settings, etc.) (Craiger et al., 2006). Comparative analysis is a method that is useful when a validated reference data source is either unavailable, or the creation of which would require a significant investment of time and resources that would imprudently delay the actual examination of the evidence (Craiger et al., 2006).

We will use a "fully-crossed" experimental design (tool suites x conditions, such as file system) where appropriate. The requirements that we will test for each suite will include: Text search in multiple formats (ASCII, UNICODE); viewing of graphical files; hash analysis (identify known good and notable files); identifying files with renamed extensions; identifying and recovering deleted files; identifying and recovering file remnants from slack space; parsing files (Window's registries, compressed, encrypted, mail boxes, etc.); file viewing; and reporting. Our law enforcement forensic examiners will assist us in identifying the specific requirements for inclusion in our study. We will disseminate the results of our studies through NIJ reports, academic publications, and conference presentations to academic and non academic audiences.

NIJ Point-of-Contact

Program Manager: Martin Novak

2009-DN-BX-K238

NY City Office of Chief Medical Examiner (OCME)

"Microscopic Analysis of Sharp Force Trauma in Bone and Cartilage"

Principal Investigator:

Dr. Christian Crowder
ccrowder@ocme.nyc.gov

Funding Amount:

$45,078 for 1 year

Abstract:

The analysis of toolmarks on bone and cartilage created as a result of sharp force trauma (SFT), including knife cuts, stab wounds, chop marks, and saw marks, is a specialized area of forensic anthropology. Current research in this specialized area has focused on identifying tool class characteristics, but lacks reported rates of precision and accuracy, which results in the absence of error rates for correctly identifying these characteristics. The deficiency in reported error rates is problematic considering results are subject to Daubert standards of courtroom-acceptable scientific evidence.

As issues of professional standards and error rates continue to be addressed in the courts, forensic scientists should be proactive by performing validation tests on new and existing methods. There has been recent increased awareness and interest in critically assessing some of the techniques used by forensic anthropologists, but issues such as validation, error rates and professional standards have seldom been addressed. Considering the recent National Academy of Sciences (NAS) report entitled Strengthening Forensic Science in the United States, the lack of attention to method validation in sharp force trauma studies is especially concerning. This proposed research will empirically test the accuracy of sharp force toolmark class characteristics on bone and cartilage (e.g. serrated vs. non-serrated blade) and establish quantifiable measures of reliability for these analyses.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K231

University of Notre Dame du Lac

"Face Annotation at the Macro-scale and the Micro-scale: Tools, Techniques, and Applications in Forensic Identification"

Principal Investigator:

Dr. Patrick Flynn
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Funding Amount:

$760,256 for 2 years

Abstract:

The value of local features in facial identification has long been established, and forms an alternative to holistic methods for automatic face recognition systems. Increases in sensor resolution, the expanding use of digital face photographs in security and criminal justice applications, and the emergence of new research to automatically detect macroscale facial features jointly motivate the development of methods for high-resolution face representation and annotation for forensic use. The PIs' prior work in face recognition and face representation provides a unique capability to investigate the area of facial feature detection, annotation, and exploitation with applications in criminal justice. The use of facial features will improve both the accuracy and speed of face recognition systems. One area of improvement is the ability to "index" matching databases (rapidly exclude large portions of the database from detailed consideration); another is an improvement in accuracy (reduced false match probability) arising from the use of a more detailed and distinctive face feature set. The goals of the proposed research are:

1. to obtain a corpus of high-resolution still and video face image data (supplementing a corpus to be collected in August, 2009 with FBI support),
2. to establish and propose for standardization a coordinate system for face images that allows for 2D or 3D location of features,
3. to establish and propose for standardization a menagerie of facial mark types that is a superset of the existing landmark annotations, exploiting facial microstructure that can now be sensed with very high-resolution cameras,

4. to develop and evaluate (using the collected corpora) methods for automatic or semiautomatic extraction of the features proposed in step 3; and
5. to document and disseminate these research results in the form of papers, reports, theses and dissertations, as appropriate.

NIJ Point-of-Contact

Program Manager: Mark Greene

2009-DN-BX-K229

Virginia Polytechnic Institute and State University

"Establishing the Quantitative Basis for Sufficiency: Thresholds and Metrics for Friction Ridge Pattern Detail Quality and the Foundation for a Standard"

Principal Investigator:

Mr. Randall Murch
rmurch@vt.edu

Funding Amount:

$854,907 for 2 years

Abstract:

Fingerprint identification depends heavily on the quality of the friction ridge pattern that an examiner or automated fingerprint identification system uses to make comparisons between known and questioned sources. High quality prints routinely allow for identification (i.e., originates from one known source) or exclusion (i.e., could not have originated from a reference sample). Otherwise, image quality based on identifiable Level 1, 2 or 3 detail can be a major source of uncertainty and potential error, or contributes to a no conclusion determination. Latent fingerprints collected at scenes of crime are often particularly problematic as they are partial, smudged or distorted. Determining print quality is a crucial step in proceeding to identification, exclusion, or no conclusion.

Currently, the assessment of print quality is subjective, does not have a welldefined quantitative basis, and is not based on standards to ensure quality and uniformity of practice. Even with automated systems that capture, transmit, and process large numbers of fingerprint images, suboptimal images routinely require human intervention, and involve the same uncertainties and issues. With either small or large quantities of fingerprint images, uncertainty and error would be reduced by establishing and validating a quantitative basis for assessing image quality for fingerprint analysis.

The proposed project seeks to establish and validate a quantitative basis for assessing image quality for fingerprint analysis purposes. Through rigorous scientific and statistical methods, the proponents intend to establish the foundation for standards to increase quality and uniformity of practice. Such standards could form the basis for defining "sufficiency" for ridge pattern analysis which would significantly improve consistency of latent print examination. This goal is consistent with the recent National Academy of Sciences report entitled Strengthening Forensic Science in the United States: a Path Forward. Latent print examiners must increasingly defend their methods and demonstrate the validity of their conclusions. The conclusions drawn and the bases for those conclusions are increasingly being criticized.

A well-grounded scientific and mathematical basis for validity and reliability of latent print examinations will go a long way to addressing these concerns and challenges. Quantitative bases and standards for assessment of pattern evidence have generally been resisted by the practitioners; the argument being that training and experience of the examiner are sufficient and that no meaningful quantitative approach exists to encompass all three levels of detail. Strong scientific foundations and standards will strengthen the practice and reliability of and confidence in fingerprint identification.

Rigorous, computationally-based studies and experiments will be performed to determine the limits of fingerprint feature visualization and discernment required for proper, reliable identification, whether captured originally as latent prints or using livescan systems. The focus of this research will be on the definability and visualization of single and combined comparative features (and their arrangements) typically used by examiners. These features and the range of quality assessed as acceptable will be done in concert with experienced, qualified examiners. Test images will be digitally captured and altered to determine drop-off points, that is, thresholds at which an area of friction ridge or feature can no longer be reliably used for identification. Metrics to quantify the amount of image alteration/distortion, such as deterioration indices, will be developed. The developed metrics will help lead to a taxonomy of image ambiguities and their associated degrees of image acceptability. Double-blind experiments will be conducted with experienced fingerprint examiners to ascertain conclusive vs. inconclusive examinations with clearly discernable vs. increasingly indiscernible features. From these studies, quantitative thresholds will be established for accurate and unbiased selection and use of Level 2 and 3 detail. Approaches developed from these studies might also be applied to other forms of pattern evidence.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K228

Western Oregon University

"Application of Spatial Statistics to Latent Print Identifications: Towards Improved Forensic Science Methodologies"

Principal Investigator:

Dr. Stephen Taylor
taylors@wou.edu

Funding Amount:

$685,754 for 2 years

Abstract:

In February 2009 the National Academy of Sciences released a report, "Strengthening Forensic Science in the United States: A Path Forward." The report is critical of the forensic science community primarily in the subjective, impression type disciplines of trace, firearms and latent prints. The report indicates the need to improve the scientific reliability and accuracy of several forensic science methodologies, including the ACE-V procedure used for latent print comparisons. In addition to this report, recent court challenges question the premise of fingerprint individuality and latent print identification accuracy due to a lack of scientific research and statistical validation of procedures employed. The goals of this proposed project are to evaluate fingerprint characteristics using established techniques in spatial statistics, determine certainty levels for fingerprint uniqueness, and quantitatively validate the existing latent print ACE-V comparison methodology..

The objectives of this project are: 1.) to evaluate fingerprint characteristics or topological attributes (e.g., minutia number, type, and position typically employed by forensic latent print analysts) using spatial statistics to derive probabilistic models for predicting fingerprint uniqueness, and 2.) to utilize the derived fingerprint probabilistic models to establish certainty levels for latent print identifications.

Objective 1 will expand on previous studies to develop the baseline statistics for various fingerprint characteristics (e.g., minutia number, type, and position, pattern type, ridge flow) by extracting fingerprint topographical data using a suite of Geographic Information System (GIS) and morphometric (e.g., NTSYSpc) software. Ten-print standards on file with the Oregon State Police (OSP), Identification Services Division will be digitally compiled, vectorized and stored in an image repository. Fingerprint characteristics will be evaluated for each digit and in multiple combinations using spatial statistical analysis software to develop a probabilistic model for fingerprint uniqueness.

Objective 2 will use Objective 1 data to develop statistical models that estimate the accuracy of ten-print to latent comparisons and certainty levels for latent identifications. The resulting model will use the most robust combination of fingerprint characteristics, topology, and spatial relationships to establish

likelihood ratios or other probability statistics for ten-print to latent comparisons. Model calibration will be based on known ten-print to ten-print matches with subsequent model verification using standard reference databases for ten-print to latent print matches (e.g., NIST Special Database 27).

The proposed project timeline and deliverables are:

- Year One (January 1, 2010 - December 31, 2010) – Develop spatial analysis protocols, digitize images, extract features, and analyze features with multiple statistical models to deliver a robust fingerprint probabilistic model.
- Year Two (January 1, 2011 – December 31, 2011) – Analyze data from year one and develop a ten-print to latent print comparison/identification probability model. Test and validate the model using ten-print standards and standard fingerprint/latent print databases respectively. Deliver a statistical latent print identification model.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K236

Intelligent Automation, Inc

"Development of Synthetically Generated LEA Signatures to Generalize Probability of False Positive Identification Estimates"

Principal Investigator:

Dr. Benjamin Bachrach
bach@i-a-i.com

Funding Amount:

$450,969 for 2 years

Abstract:

The ability to validate that an evidence bullet was fired by a suspect weapon can be of significant importance during the presentation of a case in court. For a long time the admissibility of firearms evidence rarely met significant challenges. However, Supreme Court decisions such as Daubert [1] and Kumho [2] are making it increasingly necessary to further formalize scientific evidence presented in court. The development of DNA identification techniques and the level of accuracy achievable in the estimation of error rates associated with DNA identification has raised the expectations of the quantitative precision that may be achieved in forensic analysis. In September 2008, in United States v. Glynn, Judge Jed S. Rakoff, of the federal district court for the Southern District of New York ruled that "ballistics examination not only lacks the rigor of science but suffers from greater uncertainty than many other kinds of forensic evidence" [3]. More recently, these arguments have been used in criminal trials in an effort to exclude firearms identification evidence [4], where the conclusions of the National Research Council (NRC) study [5] are widely quoted.

Thanks to the support of the National Institute of Justice (NIJ), Intelligent Automation Inc. (IAI) has completed two studies aimed at the validation of the premise that the features transferred from a barrel to a bullet are sufficiently unique to allow for a one-to-one association between the barrel and the bullets. As part of these studies, over 2800 bullets were fired, retrieved and compared using an automated ballistic analysis system developed by IAI. The statistical analysis of the results of these comparisons demonstrates that the premise of firearms identification can be validated in a quantitative manner. While these studies included a relatively large number of barrels of a variety of manufacturing qualities as well as pristine and damaged bullets, they still relied on new barrels which comprise a minute potion of those found in the street (about 11 barrels per brand/model). These limitations make it challenging to develop reliable estimates of the probability of a false positive identification for the entire universe of barrels found in the street. The main goal of the proposed study is to develop new tools to enable the generalization of these results to a much larger population of guns by creating synthetic LEAs". These synthetic LEAs would be constructed so as to resemble those found on a relatively small test set of LEAs sharing some common background (for example, corresponding to

bullets fired by the same model/make of gun). In this manner, the synthetically generated LEAs would be representative of all those LEAs having the same background as the LEAs present in the test set. At the core of the proposed study is the development of the necessary tools to provide a quantitative answer to the following question (often heard as part of a criminal trial):

What is the probability that two bullets (tool marks) with a given level of similarity could originate from two different barrels (tools)?

The proposed study leverages the significant amount of material (over 2800 test fired bullets) and techniques (algorithms for the pre-processing and comparison) developed by IAI in prior studies thanks to the support of the National Institute of Justice.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K232

Hughes Associates, Inc

“Forensic Analysis of Ignitable Liquid Fuel Fires in Buildings”

Principal Investigator:

Dr. Daniel Gottuk
dgottuk@haifire.com

Funding Amount:

$392,491 for 2 years

Abstract:

The proposed research will build off of a current NIJ grant that is aimed at characterizing the fire dynamics of liquid fuel spill fires in the open. This proposal will expand the fundamental understanding of ignitable liquid fuel (accelerant) fire dynamics when burned within an enclosure to provide a quantitative basis for assessing the utility of forensic tools, including damage patterns, fire debris sampling techniques and ignitable liquid residue measurements. Completion of the project will improve the practice of fire investigation by providing a technical basis for realistic arson and accidental fire scenarios, improving fire scene interpretation, and evaluating sampling and measurement techniques.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K225

The Regents of the University of California

"Error Rates for Latent Fingerprinting as a Function of Visual Complexity and Cognitive Difficulty"

Principal Investigator:

Dr. Jennifer Mnookin
mnookin@law.ucla.edu

Funding Amount:

$866,674 for 2.5 years

Abstract:

Understanding the frequency of errors in forensic science, and the circumstances likely to produce them, is vital both for understanding the power of forensic science and its possible limits. Knowledge about error rates is equally critical to the courts in assessing reliability under Daubert v. Merrell Dow (1993). At present, however, this information is sorely lacking. This project, investigating error rates in latent fingerprint evidence as a function of difficulty, is therefore directed at this pressing question facing forensic science today. We focus on latent fingerprint evidence, one of the most frequently used and well-established forensic sciences, but the methodology we develop can easily extend to other pattern-matching domains.

Our proposal rests on a simple but critical insight: Attributing to any forensic discipline a single "error rate" or "overall accuracy" rate is misleading, scientifically flawed, and unhelpful to forensics and the criminal justice system. Accuracy is a function of task difficulty, and not all identification tasks are created equal. Any field-wide 'error rate' occludes critical differences in task difficulty.

However, no objective metric of difficulty currently exists in the fingerprint domain. The heart of this project is to develop and validate a quantifiable metric of difficulty, and then to examine error rates as a function of difficulty. Developing such a metric is, however, not straightforward. Task difficulty certainly relates to visual complexity (the quantity and quality of information). But visual complexity, a function of the prints themselves, ignores a critical element: the forensic examiner's perception, judgment, and decision-making processes. In this proposal, we therefore develop difficulty measures that combine visual complexity measures and cognitive difficulty measures.

We first construct a database of prints where we know the ground truth (Phase 1). Phase 2 uses a variety of approaches to develop a metric of visual complexity of the prints. We then test and validate the metrics by examining cognitive difficulty, using signal detection theory (SDT), human psychophysical methods, and qualitative expert-based difficulty rating measurements (Phase 3). These results combined will permit us to develop a quantifiable and validated assessment tool, allowing a difficulty rating to be associated with any given latent print or comparison. Finally, using this hierarchy of fingerprint

comparison difficulty, we investigate the error rates, if any, associated with comparisons of varying degrees of difficulty, using ecologically valid studies with qualified and experienced latent print forensic examiners (Phase 4).

Thus, the crux of the proposed research is to quantify visual complexity in fingerprint, to relate it to cognitive difficulty, and to use these to unpack 'error rates.' Our study will provide much-needed answers regarding accuracy/error rates in fingerprints, not with a single, too-generalized field-wide error rate, but through error rates associated with a scientifically-based hierarchy of print comparison difficulty. These investigations have critically important legal implications. For example, experts will be able to report numerically to the court the accuracy/errors associated with the comparison of fingerprints, based on the difficulty of the specific prints in question. This research will also influence best practices for forensic laboratories.

Our interdisciplinary team has the experience and expertise necessary to carry out this project successfully. It includes an experienced latent fingerprint expert; a researcher with a substantial track record in forensic science-related research, specializing in expert performance and accuracy expert decision making; a cognitive psychologist with extensive experience both in measuring expertise and in examining visual complexity; and a legal scholar specializing in scientific evidence and forensic science.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K226

Indiana University

"The Information Content of Friction Ridge Impressions as Revealed by Human Experts"

Principal Investigator:

Dr. Thomas Busey
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Funding Amount:

$424,285 for 3 years

Abstract:

Current quantitative analyses of friction ridge impressions likely use only a subset of the information employed by human experts. Translating human expertise into quantitative descriptions of the information available in friction ridge impressions is made difficult by the fact that much of perception takes place below the level of conscious awareness and is difficult to translate into language. We approach this problem by collecting eye tracking data from experts to document the regions and features they visit. We use data reduction procedures to infer a feature or basis set, and then use this to derive information metrics that provide a complete quantitative description of the information available in friction ridge impressions given a particular feature set and metric. The range of potential information metrics is large, and we will use a recursive testing methodology that uses data reduction procedure to obtain an initial feature set, which will then be used to generate candidate information metrics. These metrics will then be tested using a combination of noise masking and feature elimination procedures depending on the metric used. We will explore a range of metrics as well as combinations of information sources to reflect the fact that experts may use a wide variety of different types of features. The final test will come when we use the metrics to predict the eye fixations of experts on new sets of fingerprints, which will demonstrate that the experts and our quantitative analysis both rely on similar sources of information as a way to validate our analyses. The specification of a metric also allows us to determine which features are most diagnostic and point out when experts are using sub-optimal search strategies. Finally, we will use the data to identify different search patterns that are associated with the different steps involved in the ACE-V methodology, and reveal behaviors that lead to errors.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K227

University of Central Florida

"Statistical Assessment of the Probability of Correct Identification of Ignitable Liquids in Fire Debris Analysis"

Principal Investigator:

Dr. Michael Sigman
msigman@mail.ucf.edu

Funding Amount:

$415,992 for 3 years

Abstract:

Identification of ignitable liquid residues in the presence of background interferences, especially those arising from pyrolysis processes, is a major challenge for the fire debris analyst. The proposed research will lead to a mathematical model that allows for the detection of an ignitable liquid in a fire debris sample and the classification of the ignitable liquid according to the ASTM E 1618 classification scheme. The research will examine the influence of substrate pyrolysis and non-pyrolysis interferences on: (1) probability of correct prediction of the presence of an ignitable liquid in real and simulated fire debris samples (Type I and Type II error rates) and (2) probability of correct prediction of the associated ignitable liquid ASTM class and sub-class (heavy, medium or light) in positive samples. Potential alternative sub-groupings of ignitable liquids will be examined based on cluster analysis techniques. Models will be examined which are based on principal components analysis (PCA), linear discriminant analysis (LDA) and soft independent model classification analogy (SIMCA). The model will be developed from the summed ion spectra of nearly 500 ignitable liquid and 50 pyrolysis sample GC-MS datasets with ANOVA-assisted variable selection. Training data sets will be taken from the National Center for Forensic Science ignitable liquid and substrate pyrolysis databases. Simulated fire debris samples generated in the laboratory and samples from large-scale burns will also be employed in model testing. Model performance will be statistically evaluated by receiver operator characteristic analysis. The final model will be implemented in a software solution for forensic laboratory use.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-BX-K233

Virginia Polytechnic Institute and State University

"Fundamental Research to Improve the Understanding of the Accuracy, Reliability, and Validity of Using the ENF Criterion for the Forensic Authentication of Digital Recordings"

Principal Investigator:

Dr. Richard Conners
rconners@vt.edu

Funding Amount:

$864,638 for 3 years

Abstract:

Forensic audio refers to audio material that may provide evidence in legal proceedings. The authenticity and originality of audio evidence must be evaluated using standardized procedures to prove that it has not been changed since the time of its production. Methods for the forensic examination of analog recordings are well established [3-5]. However, digital recordings have now become more commonplace than the analog variety. The signal characteristics associated with digital recordings are completely different than those of analog, and additional techniques for assessing the integrity of a suspect digital recording are required. One such technique is the Electric Network Frequency (ENF) Criterion. The preliminary concept was proposed in continental Europe by Grigoras in 2003. ENF embedded in digital recordings relate to the frequency of the power system in the location where the recording was made. ENF variation is a naturally-occurring wide-area phenomenon that is caused by imbalances between the generated power and the load on the network. The variations that do occur under stable operating conditions are the same for all points in the network or grid. These frequency variations are random and, as such, for long enough periods of time it is assumed that these patterns are unique and hence can be used in the verification of digital recordings. The ENF criterion is based on estimating the electric network frequency that may occur in a digital recording. This frequency variation is then compared to the ENF that has been directly measured from the network or to an ENF estimate made from a recording of known validity. Thus, extracted ENF data from a digital recording may be compared to an available reference database of ENF information recorded in a lab or obtained from the utilities, allowing the date and time of the recording to be ascertained.

Additionally, it may be used to establish if and where the recording has been edited. While the feasibility of using ENF for the forensic examination of digital recordings has been demonstrated, little fundamental research into the basic approaches for using this information has been conducted. The goal of this proposal is to do the fundamental research needed to improve the understanding of the accuracy, reliability, and measurement validity of using the ENF Criterion in the forensic analysis of digital recordings. What makes this research possible is the data collected by the Frequency monitoring Network (FNET) developed at Virginia Tech. It collects ENF data in real time from all three power grids in

the U.S. and indefinitely archives this data as it is collected. Besides performing the fundamental research needed to better understand the ENF Criteria, the proposed work includes creating a best practices guide for use by the nation's law enforcement agencies that want to use ENF in their investigations. Obviously, to accomplish this, the research that is conducted must remain well-focused so that it concentrates on those issues that are most pressing. To keep the needed focus, this team intends to work very closely with the Scientific Working Group on Digital Evidence (SWGDE). In particular we intend to work closest with the Digital Audio subcommittee of this working group. To help establish this close working relationship, we intend to send representatives to the two meetings the SWGDE has each year, to invite members to meet with us on a more regular basis, and to seek as much input as we can from them as to the directions the research should pursue.

NIJ Point-of-Contact

Program Manager: John Kaplan (John.Kaplan@ojp.usdoj.gov)

2009-DN-BX-K234

George Mason University

"Quantifying the Effects of Database Size and Sample Quality on Measures of Individualization Validity and Accuracy in Forensics"

Principal Investigator:

Dr. Christopher Saunders
csaunde6@gmu.edu

Funding Amount:

$974,981 for 3 years

Abstract:

This proposed project will address several of the concerns detailed in Recommendation 3 in the National Academy of Science (NAS) report: Strengthening Forensic Science in the United States: A Path Forward. Specifically, we propose to develop methods to statistically quantify (1) the uncertainty in measures aimed at validating a forensic discipline's basic premises (such as a uniqueness claim) and (2) the use of likelihood ratio methods in making classification/individualization conclusions. The use of automated pairwise comparisons of biometric samples in a database is a basic element of forensic individualization determinations involving biometrics such as fingerprints and handwriting. An issue that applies to forensic individualization is that while a database of samples can be used to support individuality, it does not necessarily prove individuality. Therefore, the NAS report calls for statistically/probabilistically based statements concerning the level of support that a database of samples provides for individualization. To date, much attention has focused on how to use an automated comparison methodology applied to a database of samples to estimate the random match probability (RMP), which is defined as the probability of selecting two individuals at random from a population that "match" on the basis of some biometric. The RMP can be interpreted as giving the expected performance of a comparison methodology across some relevant population. Phase I of this proposed project will focus on the RMP as a measure of the validity of a forensic individualization procedure. We propose to develop theoretically sound upper confidence bounds on measures, such as the RMP, that are estimated using these automated pairwise comparisons. In Phases II and III, we will shift focus to quantifying accuracy with likelihood ratio methods. The use of likelihood ratio methods in DNA analysis is well established. However, research into its use in other forensic areas is not as well developed. We propose to investigate its estimation in other fields, such as handwriting and glass fragments, focusing both on statistically sound point estimates and confidence intervals. Since the RMP in many instances is related to the denominator of the likelihood ratio, Phase II and Phase III will build on the results from Phase I. In Phase II, we will focus on nonparametric estimation procedures while in Phase III, we will investigate parametric techniques including some Bayesian approaches to the problem of calculating the likelihood ratio. Parametric methods require additional assumptions be made about the underlying samples being

used in the estimation. So, one component of Phase III will be comparison of the parametric and nonparametric estimates of likelihood ratios to better understand what is gained or lost via the additional assumptions. Most of the methodologies developed in this proposed project will apply to any field of forensics as RMPs and likelihood ratios are defined similarly in many of them. In all three phases, we will be quantifying the effect of database size and sample quality on proposed point and interval estimators. Finally, in all three phases, we plan on illustrating the developed methodology on available data.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2009-DN-R-119

Ames Laboratory

"Manipulative Virtual Tools for Tool Mark Characterization"

Principal Investigator:

Dr. Song Zhang
song@iastate.edu

Funding Amount:

$360,000 for 2 years

Abstract:

Challenges to objective optical comparison of markings (e.g. firearms or tool marks) by an expert examiner have caused a need for accurate and reliable quantitative data analysis tools based on quantitative measurements to improve the scientific basis of toolmark identification. Tool mark examinations are inherently more difficult to quantify than firearms since standard conditions (e.g. shape, size) do not exist and a mark can vary depending upon the angle of attack, applied pressure, or twist of the tool employed. The "mark" left by the tool may be a series of markings of different size, depth, length, etc. What is desired is a quantitative technique where a single data set related to the employed tool can be matched to all of the disparate markings left on a surface. The goal of this proposal is to develop a methodology whereby a three-dimensional (3-D) computer simulation of a tool tip is generated. This "virtual tool" can then be used to produce "virtual toolmarks" - a series of predicted markings where the applied force, twist of the tool, and angle of attack of the tool tip can be varied. Quantitative 3-D data from the suspected tool and evidence toolmark will be acquired and a virtual reality program developed that takes this data and reconstructs a "virtual tool" for computer manipulation to create "virtual tool marks". Since the "virtual tool" can be manipulated to produce a range of markings, the exact parameters required to obtain the best possible match to the actual tool mark can be found. Duplicate marks based on these results can then be statistically compared and ranked on the basis of quantitative measurements. If successful the project should increase the accuracy and validity of toolmark identification by providing quantitative, scientifically testable and verifiable data.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

#4. Forensic DNA Research and Development

Posting Date: November 13, 2008

Closing Date: December 29, 2008

Awards Made: 18

With this solicitation, NIJ sought applications for research and development that can enhance the forensic uses of DNA technology. This solicitation focused on technologies that result in faster, more robust, more informative, less costly, or less labor-intensive identification, collection, preservation, and/or analysis of DNA evidence collected from crime scenes. Specifically, this solicitation focused on:

- General improvements to the "front end" of the forensic DNA analysis process.
- Physical separation of the components of a mixture.
- Body-fluid/cell-type identification and characterization.
- Identification and/or characterization of biological marker systems that have the potential to reveal additional or more powerful information about the source of the biological evidence.
- Improved tools for examining aged, degraded, limited, damaged, inhibited, or otherwise compromised DNA evidence.
- Novel methods for genetic profiling.

FY 2009 Forensic DNA R&D Awards

Grant Number	Grantee	Title	Page #
2009-DN-BX-K039	Paternity Testing Corporation	Automated Processing of Sexual Assault Cases Using Selective Degradation	Pg. 56
2009-DN-BX-K043	City and County of Denver; Denver Police Department	Denver Police Department, Crime Laboratory Bureau: Forensic DNA Research and Development - Sperm Capture Using Aptamer Based Technology	Pg. 58
2009-DN-BX-K047	Colorado Seminary, which owns the University of Denver	Development of Linkage Phase Analysis Software for Resolving mtDNA Mixtures	Pg. 60
2009-DN-BX-K165	Colorado Seminary, which owns the University of Denver	Validation of Highly-Specific Protein Markers for the Identification of Biological Stains	Pg. 62
2009-DN-BX-K178	The George Washington University	Development of a SNP Assay Panel for Ancestral Origin Inference and Individuals Somatic Traits	Pg. 64
2009-DN-BX-K179	The University of Central Florida	Predicting the Biological Age of a Bloodstain Donor	Pg. 65
2009-DN-BX-K180	The Regents of the University of California	Microchip Analyzer for Forensic Short Tandem Repeat Typing of Single Cells	Pg. 66
2009-DN-BX-K181	Science Applications International Corporation	Next Generation Sequencing-based STR Mixture Deconvolution and STR Profiling of Degraded Samples	Pg. 67
2009-DN-BX-K186	The Research Foundation of SUNY	Application of Raman Spectroscopy for an Easy-to-Use, on-Field, Rapid, Nondestructive, Confirmatory Identification of Body Fluids	Pg. 68
2009-DN-BX-K187	General Electric Company	Automated Processing of FTA Samples	Pg. 69

2009-DN-BX-K039

Paternity Testing Corporation

"Automated Processing of Sexual Assault Cases Using Selective Degradation"

Principal Investigator:

Ms. Kim Gorman
Kim@ptclabs.com

Funding Amount:

$294,360 for 2 years

Abstract:

The goal of this research is to produce an automated format for processing sexual assault evidence that will be faster, easier, and more cost effective than the current available methods of differential extraction, and will produce superior results.

By some estimates, there are hundreds of thousands of sexual assault cases waiting to be processed. By producing an automated system of processing the sexual assault evidence and producing high quality single source DNA profiles from the sexual assault evidence, many more cases will be solved. Many more profiles will be eligible for entry into CODIS, and more offenders will be identified.

The standard differential lysis method for processing sexual assault cases relies on separation of intact sperm from the contaminating DNA of lysed epithelial cells by centrifugation, careful removal of supernatant, and multiple washing steps that are labor intensive and result in sperm loss. Numerous efforts to improve this process have assumed that the contaminating victim's DNA must be physically separated from the sperm, and yet an entirely different approach is possible. After a pipetting step to remove the victim DNA fraction, the contaminating victim DNA remaining in the sperm fraction can be destroyed using selective degradation. Addition of a degradative agent is inherently easier and much more effective than physically diluting and washing away the remaining victim DNA from the sperm pellet. The selective degradation process requires only a single pipetting step. For such a method to work, the degradative agent must be selective for soluble DNA and it must be active in the extraction buffer that is used to elute the sperm from the swab cutting and to lyse the epithelial cells. We have found that DNase I does not digest sperm DNA present in intact sperm heads, while it does digest more than 99.9% of soluble epithelial cell DNA following Proteinase K (ProK) digestion. Importantly, DNase I is inactivated by the sodium dodcecyl sulphate (SDS) present in the standard ProK buffer used to process sexual assault cases, and substitution of Triton X-100 for SDS in the ProK buffer is essential for this process to work, as Triton X-100 does not inhibit DNase I. ProK, being an unusually robust enzyme, is active in both SDS and Triton X-100. The inhibition of DNA nucleases by SDS and Sarkosyl (another detergent used for processing sexual assault cases) is the most likely explanation for the failure of

previous unpublished attempts at selective degradation as a means of removing the unwanted DNA belonging to the victim.

Initial results, presented in this proposal, show that a vaginal swab taken from a rape victim gives a superior male DNA STR profile when processed with the nuclease protocol compared with the standard protocol. The epithelial victim fraction is obtained by removing an aliquot of soluble DNA before nuclease addition. An article describing our success with the nuclease method will be published in the Journal of Forensic Sciences in September 2009 (manuscript JOFS-08-414). This nuclease approach does not require any additional centrifugation or filtration steps, or use of complex machinery, and it can be readily automated. The centrifugation step that is used in order to remove the liquid from the swab or fabric containing the forensic stain will also pellet the sperm heads. The victim fraction can be pipetted at this stage and no further centrifugation steps are necessary. The current proposal addresses the need to validate this promising new approach for processing sexual assault cases in an automated fashion using a 96 well plate format and multichannel pipettors, and finally with robotic workstations.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K043

City and County of Denver; Denver Police Department

"Denver Police Department, Crime Laboratory Bureau: Forensic DNA Research and Development - Sperm Capture Using Aptamer Based Technology"

Principal Investigator:

Dr. Greggory LaBerge
Greggory.Laberge@denvergov.org

Funding Amount:

$405,812 for 2 years

Abstract:

The majority of samples in forensic casework originate from sexual assault cases. These samples are usually mixed samples of male and female DNA. The forensic challenge lies in the separation of this mixture with the goal of isolating the male DNA profile. Differential DNA extraction methods exist, however, they are currently labor intensive and time consuming.

Aptamers are single-stranded nucleic-acid molecules with the molecular recognition properties comparable to antibodies, although often with even higher specificity. The applications of aptamer technology are numerous, and there are very few areas of research where aptamers are not currently being utilized. We will take advantage of the enormous specificity and synthetic nature of aptamers to achieve useful separation and isolation of spermatozoa prior to DNA extraction.

In collaboration with SomaLogic Inc., a leader in aptamer technology, the Denver Police Department Crime Laboratory Bureau proposes to develop a method to specifically capture spermatozoa from mixed sexual assault evidence and allow for the amplification of separated male DNA as well as DNA from the recovered non-sperm cell fraction. This method would create a pool of aptamers that bind to sperm-specific surface proteins. The advantage of utilizing aptamer technology lies in the possibility of binding the aptamers specifically to their target proteins, thereby immobilizing entire sperm cells while avoiding binding of epithelial and other non-sperm cells. The assay will allow for the immobilization of spermatozoa on a solid matrix, such as a coated 96-well plate, beads, or other suitable matrices. It would enable separation of sperm heads from epithelial cells and non-sperm semen components by stringent washing protocols that would typically disassociate antigen-antibody complexes. This sperm-

capture assay can be automated for high-throughput processing and could therefore greatly decrease the amount of time required to develop male DNA profiles from sexual assault evidence in a cost effective manner.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K047

University of Denver – Colorado Seminary

"Development of Linkage Phase Analysis Software for Resolving mtDNA Mixtures"

Principal Investigator:

Dr. Phillip Danielson
pdaniels@du.edu

Funding Amount:

$42,646 for 1 year

Abstract:

A mixture of different mtDNA molecules in a single sample presents a significant obstacle to successful mtDNA analyses by standard methods. Under NIJ DNA Research and Development Award 2003-IJCX-K104 we have developed and rigorously validated a method for the accurate, rapid and low-cost fractionation and analysis of DNA mixtures. Based on Denaturing High-Performance Liquid Chromatography (DHPLC), this technique enables sequence-specific separation of both situational and natural mtDNA mixtures prior to sequencing without PCR reamplification or excessive sample manipulation. Coupled with linkage phase analysis of the post-fractionation sequencing electropherograms, the haplotypes of the individual contributors to the mixture can then be reliably determined. While the statistical confidence of resolving mixtures using this approach typically exceeds 99.9%, the computationally intensive nature of the underlying mathematics is prohibitively time consuming. If DHPLC-based mixture resolution is to be employed for the analysis of case work, a robust software application is needed to automate data analysis.

The current proposal, therefore, is to develop, test and release a solidly reliable software application for linkage phase analysis. A prototype application termed FLiPARS developed under our prior NIJ award demonstrates the feasibility of a software solution but lacks the robust stability and intuitive user interface required for production use by practitioners. To resolve the deficiencies identified in the prototype application, an improved program design based on use of the C# programming language and a .NET foundation is proposed. Specifically, the revised software will be written to eliminate dependencies on secondary software applications in favor of a modularized system of plug-ins. This approach has a number of significant advantages as it allows virtually any developer to make use of a standard format for data input. This will alleviate any intellectual property concerns that sequencer manufacturers may have regarding proprietary data output files that come from their instruments. The redesigned architecture will also greatly improve the speed at which linkage phase analyses are performed. The end product will be a software application that is simple to use, reliable and malleable for future changes in the field.

Collaboration with practitioners experienced in the vicissitudes of mtDNA sequence analysis will help to guide this software development to best meet the needs of the forensic community. Furthermore, the performance of the software will be rigorously evaluated using a large dataset of several thousand sequencing electropherograms generated from two-component mtDNA mixtures prepared at stepped ratios from 1:99 to 99:1. This will be coupled with a second series of performance tests on forensic casework-type mtDNA mixtures involving a diversity of tissue sources, substrates and environmental insults.

The availability to practitioners of a relatively simple and efficient means of analyzing electrophoretic data - and thereby resolving the haplotypes of mtDNA mixtures - is the last essential component needed to put an already validated solution for mtDNA mixture analysis in the hands of practitioners. The impact of doing so will enable criminal investigators to obtain potentially probative information from samples that historically have not been amenable to analysis by direct sequencing.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K165

Colorado Seminary, which owns the University of Denver

"Validation of Highly-Specific Protein Markers for the Identification of Biological Stains"

Principal Investigator:

Dr. Phillip Danielson
pdaniels@du.edu

Funding Amount:

$243,427 for 1 year

Abstract:

The advent of DNA profiling has transformed the field of forensic serology by making it possible to individualize biological stains. The identification of the stain itself, however, can present a challenge for forensic serologists. For example, there is no test for vaginal secretions and tests for blood cannot distinguish peripheral from menstrual blood even though this information can be probative to an investigation. In 2006, we proposed the use of a comparative proteomics approach to identifying high-specificity candidate biomarkers of biological stains. Under NIJ award 2006-DN-BX-K001 we have successfully mapped and rigorously compared the proteomes of five individuals for six body fluids with clear forensic relevance (i.e., peripheral and menstrual blood, vaginal secretions, semen, urine and saliva). Based on these analyses, we have been steadily building a database of candidate protein biomarkers of our target stains. These include anticipated protein biomarkers like statherin for saliva and lesser known ones like periplakin for vaginal secretions. Having been identified from analyses of just five people, however, it cannot be overemphasized that these are candidate biomarkers.

The current proposal, therefore, is to validate the specificity of the most promising candidate biomarkers for their target body fluids and the consistency of their expression among multiple humans. This will make it possible to discriminate between proteins that are specific to a given body fluid vs. those that show interindividual variability or which are present in non target stains. The choice of the bodily fluids to be analyzed and the size of the study population reflects discussions with forensic serologists at the Colorado Bureau of Investigation and other forensic practitioners. In addition to assays of an expanded study population, a second set of validation studies will assess the stability and reliability of these biomarkers in a forensic context. Specifically, the ability of the biomarkers to persist and be detected in single source and mixed samples recovered from a variety of substrates or exposure to environmental contaminants/insults will be assessed.

Biomarker validation assays will be conducted using a high-sensitivity mass spectrometry technology (Q-TOF). This will enable the detection of even low-abundance candidate biomarkers while circumventing the obstacles of alternative approaches that would be prohibitively expensive and unnecessarily time consuming. Pilot studies on candidate biomarkers for human saliva and seminal fluid support the

feasibility of this approach. By rigorously selecting for biomarkers that are both reliably expressed in nearly all humans but highly-specific to a target body fluid, the proposed research will provide the forensic community with a panel of biomarkers that can be used to create a low-cost multiplex assay for biological stain identification using technology similar to that seen with ABAcard and Seratec® kits. The proposed research will be conducted on a 1-year timeline by scientists specifically skilled in forensic biology and proteomics. Collaboration with practitioners from the Colorado Bureau of Investigation and an expert in the forensics of sexual assault examination will help to guide this research to best meet the needs of the forensic community.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K178

The George Washington University

"Development of a SNP Assay Panel for Ancestral Origin Inference and Individuals Somatic Traits"

Principal Investigator:

Dr. Daniele Podini
podini@gwu.edu

Funding Amount:

$255,918 for 2 years

Abstract:

When a Short Tandem Repeat DNA profile obtained from evidence collected from a crime scene does not match identified suspects or profiles from available databases then further DNA analyses, targeted at inferring the possible ancestral origin and phenotypic characteristics of the perpetrator, can be a valuable investigational tool. Such a tool would aid in prioritizing suspect processing, corroborating witness testimony, aid in the determination of the relevance of a piece of evidence to a crime, and ultimately increase the ability to identify individuals related to the crime scene. Single Nucleotide Polymorphisms (SNPs) are the most common form of genetic polymorphisms present in the human genome. A large number of these, both on the nuclear and mitochondrial genomes, have alleles that are associated with either specific populations and/or correlated to specific somatic traits. Single Base primer Extension (SBE) is an effective and sensitive technology that can type over 30 loci throughout the genome in a single reaction. We propose to develop a panel of robust and sensitive assays for ancestry and somatic traits using the SBE technology. The goal of this project is to develop an analytical tool that can use the technology currently available in forensic DNA laboratories and could be implemented in a kit form to be used on casework as needed.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K179

The University of Central Florida

"Predicting the Biological Age of a Bloodstain Donor"

Principal Investigator:

Dr. Jack Ballantyne
jballant@mail.ucf.edu

Funding Amount:

$300,450 for 2 years

Abstract:

Biological samples from crime scenes are routinely analyzed in an attempt to determine the identity of the depositor. Forensic DNA analysis techniques employ a battery of non-coding STR loci to determine individuality by direct comparison of a crime scene sample and a reference sample. No information about the physical characteristics of the donor can be gleaned from the STR profiles per se. However the ability to predict some key physical features of an individual by assaying appropriate specific biomarkers from crime scene samples would greatly aid criminal investigations. Recent progress has been made in identifying biomarkers associated with physical characteristics such as hair-, skin- and eye- pigmentation and bio-geographic ancestry but other physical features may be similarly amenable to genetic analysis.

In the proposed work we aim to identify age-specific biomarkers with the ultimate aim of designing assays that may be used to predict the biological age of a sample donor. An individual's age is innately associated with genetic changes. Several metabolic and biochemical processes within the body are key to specific developmental stages in a person's life and these are regulated by specific genes. Thus the possibility exists of finding an association between patterns of mRNA expression of such regulatory genes, and the genes that they regulate, and specific stages of life. We will take a two-pronged approach to biomarker identification. The first strategy will be to analyse the entire transcriptome of selected samples of different ages, using deep sequencing mRNA-Seq technology, in order to identify candidate genes that show different expression with respect to the age of the donor. The second approach involves targeting specific candidate genes that are, or are likely to be, involved in regulation of age-related processes based upon a priori understanding of the physiology and biochemistry of human development.

Candidate genes identified by either strategy will be used to design multiplex assays. Both CE- based and quantitative reverse transcriptase PCR platforms will be used. SWGDAM developmental validation studies will be carried out on those bioassays initially demonstrating the most promising specificity and sensitivity performance.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K180

The Regents of the University of California

"Microchip Analyzer for Forensic Short Tandem Repeat Typing of Single Cells"

Principal Investigator:

Dr. Richard Mathies
ramathies@berkeley.edu

Funding Amount:

$241,117 for 2 years

Abstract:

This grant will develop devices and methods for single-cell forensic short tandem repeat (STR) typing using a microfabricated single-cell genetic analyzer (SCGA) that integrates single-cell capture, nanoliter-volume PCR amplification, integrated quantitative post-PCR sample cleanup, inline injection and CE separation. A PCR-capture-CE microchip that integrates PCR, product cleanup through integrated capture, inline injection and CE will be first developed and evaluated using standard genomic DNA samples. Then this device will incorporate a cell capture structure for accurate single-cell loading and will be further optimized for single-cell STR typing. Individual Jurkat cells will be typed repeatedly with the SCGA to obtain data for evaluation of "stochastic effects" and PCR kinetics at the nanoliter volume scale, as well as for overall assessment of system performance. Further evaluation of this microsystem for forensic mixture and low-copy-number DNA analysis will be performed by typing non-probative samples. This integrated and fully automated microdevice for forensic STR typing should provide a unique approach to mixture sample analysis; the enhanced detection capability should also be useful for typing of LCN samples. This new method will be critically tested and disseminated with the help of the Virginia Department of Forensic Science (VDSF) and the Palm Beach Sheriff's Office (PBSO).

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K181

Science Applications International Corporation

"Next Generation Sequencing-based STR Mixture Deconvolution and STR Profiling of Degraded Samples"

Principal Investigator:

Dr. Diane Rowold

Ms. Cindy Nye (Point-of-Contact)
cindy.l.nye@saic.com

Funding Amount:

$241,117 for 1 year

Abstract:

This proposal, submitted by Science Applications International Corporation (SAIC), describes an efficient method of DNA capture for productive CODIS STR analysis of forensic DNA samples. This targeted capture process filters out non-specific genomic regions, sub-optimal template, PCR inhibitors, and non-human components which may interfere with the amplification of the desired STR loci. Once developed, this front end procedure can then be used to facilitate the resolution of two critical issues in the field of forensic DNA: (1) CODIS STR mixture de-convolution, and (2) CODIS STR profiling of low template DNA samples. The first of these, DNA mixture de-convolution, poses one of the greatest challenges for the forensic community. The resolution of DNA mixtures into single component STR profiles is a high-need capability that does not currently have an adequate technical solution. Current analytical methodologies introduce sample proportion bias caused by the communal nature of traditional PCR, provide unsatisfactory quantification of the resulting amplicons, and suffer from artifacts such as stutter, non-template adenylation and allelic dropout. The focused capture technique developed here in combination with the clonal amplification of CODIS STRs via emulsion PCR (emPCR) followed by a powerful Next Generation DNA Sequencing (NGS) analysis may, in the future, offer a new approach to overcome current technical limitations and effectively resolve individual CODIS STR profiles from mixed DNA samples.

Targeted capture enrichment, followed by CODIS profiling (using either the conventional SOP or the more cutting edge emPCR/NGS methodology) may also improve the processing of low template DNA (<100 pg) samples. Samples enriched for human DNA regions are targeted should perform substantially better in Whole Genome Amplification (WGA) since most of the non-human template competing for the WGA reagents will be filtered out.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K186

The Research Foundation of SUNY

"Application of Raman Spectroscopy for an Easy-to-Use, on-Field, Rapid, Nondestructive, Confirmatory Identification of Body Fluids"

Principal Investigator:

Dr. Igor Lednev
lednev@albany.edu

Funding Amount:

$374,395 for 2 years

Abstract:

A novel method based on Raman spectroscopy will be developed for nondestructive, confirmatory identification of body fluids in biological stains discovered at a crime scene. A library of Raman signatures for various body fluids will be built and software for unknown sample analysis will be developed. The method will be optimized for practical applications, including stains on various substrates and contaminated mixtures.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K187

General Electric Company

"Automated Processing of FTA Samples"

Principal Investigator:

Dr. Erin Finehout
finehout@research.ge.com

Funding Amount:

$499,967 for 1 year

Abstract:

The number of samples being submitted into forensic labs for short tandem repeat (STR) analysis and databanking is increasing every year. One commonly used material for the collection and storage of these samples is FTA® paper. Although FTA paper is effective for long-term room- temperature storage of DNA, there is no single automation solution that covers all the steps of sample handling and preparation for PCR. GE Global Research proposes to build a bench-top prototype that demonstrates proof of concept for automation of the entire FTA workflow (e.g., FTA card in and DNA out). The team proposes to focus on solutions that offer improvement in the overall throughput and reproducibility of the process. The Northeast Regional Forensic Institute (NERFI) and the New York State Police Forensic Investigation Center will collaborate on this project to ensure the system is compatible with the regulations, workflow, and requirements of a high-throughput forensic lab. The end product of this project will be a design for a system to automate the handling of FTA cards, and proof-of concept data from a bench-top prototype that demonstrates that the system will meet the needs of a forensic lab. A final report summarizing the results will be submitted at the end of the project.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K188

UNT Health Science Center at Fort Worth

"Improved Tools and Interpretation Guidelines for Examining Limited Low Copy Number DNA Obtained from Degraded Single Source Samples: Bones, Teeth, and Hairs"

Principal Investigator:

Dr. Bruce Budowle
bbudowle@hsc.unt.edu

Funding Amount:

$935,992 for 2 years

Abstract:

Low copy number (LCN) typing can be defined as the analysis of any sample that contains less than 200 pg of template DNA or where the stochastic effects during PCR are so exacerbated that, for STR analysis purposes, peak height imbalance, allele dropout, and increased stutter are observed. We propose studying LCN techniques from single source samples such as bone, teeth, and hairs. LCN typing first should be defined for single source samples so that a solid foundation can be laid before proceeding to more complex mixture profiles. Mixed DNA profiles are more commonly encountered with touch samples and pose additional challenges in interpretation and confidence. Controversy has arisen regarding the use of LCN typing because of its lack of robustness. The NDIS Procedures Board released a bulletin in August 2008 prohibiting the upload of LCN DNA profiles into NDIS. This may be due to the lack of confidence by the NDIS Procedures Board regarding the reliability of LCN typing results and little or no defined guidelines for the application of LCN typing and the interpretation of its typing results.

We propose a 2-year study to better define LCN typing by conducting nine different areas of research. Each area assesses a specific aspect as it relates to the analysis of LCN DNA samples from single source samples: 1) improve extraction efficiency of DNA from skeletal remains.; 2) evaluate the performance of the predominant methods for increasing sensitivity of detection for LCN typing; 3) enhance robustness of the amplification by PCR for LCN samples; 4) increase the amount of the starting template molecules by whole genome amplification using emulsion PCR; 5) increase the amount of starting template molecules by template circularization and rolling circle amplification; 6) test the efficacy of typing the same template multiple times; 7) test the efficiency of mini STRs for typing LCN samples and develop proper stochastic thresholds; 8) develop positive controls or validation samples for LCN typing; and 9) develop reliable interpretation guidelines and statistical protocols for evaluating the significance of single source LCN profiles The results from these studies should lay the foundation for using LCN typing for single source samples, such as those that typically represent human remains. The findings from this research grant will enable more identifications with better assessments of degrees of confidence than are now possible. The data will enable the community and the NDIS Board to better appreciate what constitutes a LCN sample and what are the salient features necessary to validate its use, as well as

realize that identification of human remains and and touch samples are very different applications of LCN typing. Also and even more importantly, once single source analyses are well-defined, then developmental and validation studies can be devised to address more complex LCN or touch sample evidence such as those found in high volume crime.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K189

Akonni Biosystems Inc.

"A Low Cost Microfluidic Instrument for Typing SNPs"

Principal Investigator:

Dr. Jennifer Reynolds
jreynolds@akonni.com

Funding Amount:

$495,031 for 1 year

Abstract:

The goal of this work is to design, build, and test an integrated microfluidic controlled microarray test for SNP typing. In Phase I, we demonstrated feasibility of Akonni's gel drop microarray platform as a complete solution for forensic SNP-typing applications. Sample preparation, PCR, and the microarray were packaged into prototype flow-through microfluidic modules for Y-chromosome SNP discrimination. Phase II will focus on refining protocols and assay chemistries, and packaging components and reagents into an integrated system for automated, sample-to-answer results. The system will consist of the instrument (i.e., liquid handling, Akonni Bladder Thermal Cycler, Akonni Reader, and cartridge docking station) and a disposable, integrated cartridge (i.e., Akonni TruTip, Akonni PCR and TruArray flow cell chambers, microfluidic circuits, and microfluidic valves). Emphasis will be placed on refining fluid paths (e.g., minimize the number of paths and path lengths), liquid handling and fluidic control (e.g., pumps and valve types and configurations), molding of the disposable plastic cartridge parts, software and graphical user interface, and instrument footprint (approximately 2-3 cu.ft). Protocols and assays will be streamlined for minimum complexity, time, and cost. assays will be transitioned from Y-chromosome markers (served as a model in Phase I) to phenotype markers for physical appearance (e.g., eye color) in Phase II. In addition, assay reagents (e.g., PCR, AS-APEX) will be converted to a lyophilized format for long term storage and field deployment.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K209

Research Foundation of CUNY c/o John Jay

"Application of Proteinases for DNA Isolation of Challenged Bone Specimens"

Principal Investigator:

Dr. Richard Li
RLi@jjay.cuny.edu

Funding Amount:

$33,037 for 1 year

Abstract:

Forensic analysis of DNA from bone can be important in a variety of situations, including mass fatality incidents; the identification of the skeletal remains recovered from war, fires, or explosions; and in cases involving the identification of skeletal remains in criminal matters.

However, bone is difficult to process for isolating DNA. Thus, we propose to develop a simple trypsin method for processing challenged bone specimens prior to DNA isolation. Our previous results, tested on fresh human bone samples, have suggested that the trypsin method can be potentially useful for forensic DNA analysis. In this proposal, additional studies will be done on samples that are more typically encountered in actual forensic cases. If these proposed studies are successful, the method can be an alternative cleaning method to physical cleaning procedures, such as sanding. First, this method can be less time-consuming and less labor intensive for processing bone samples than physical methods. Second, this method could be adapted for the automated processing of bone samples for DNA isolation to improve the throughput; while physical methods are difficult to adapt for automation. Third, trypsin is reasonably inexpensive. Additionally, the labor cost for this method will be reduced. Thus, the overall cost of this method should be lower than physical methods. Last, this method has a low potential risk of cross-contamination between samples and diminishes safety concerns for laboratory analysts due to exposed bone powder generated by physical methods. This proposed study has the potential to make a significant impact on the processing of skeletal remains from mass fatality incidents and missing-person casework for the forensic community and the law enforcement agencies.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K250

The Bode Technology Group, Inc.

"Identification and Separation of Evidence Mixtures Using SNP-Based FISH Techniques and Laser Microdissection"

Principal Investigator:

Dr. Robert Bever
robert.bever@bodetech.com

Funding Amount:

$320,021 for 1 year

Abstract:

Laser microdissection (LM) has proven to be an effective method for cell mixture separations in the forensic laboratory. While sperm and epithelial cell sexual assault mixtures can easily be separated based upon morphological differences, mixtures of the same cell type are more difficult to separate. During our work on NIJ Contract# 2006-DN-BX-K032, we have developed the capability to successfully separate male/female cellular mixtures of similar morphology using chromosome X/Y Fluorescent In Situ Hybridization (FISH) probing. In the cases of cellular mixtures of same gender, we believe that developing fluorescent probes based upon human genetic single nucleotide polymorphisms (SNPs) to create additional FISH screening methods could provide a basis for separation of these samples with LM instruments. Screening panels of FISH SNP probes could effectively visually detect individual contributors of sample mixtures while LM technologies could physically separate the cells for further STR processing. Multiple improvements in LM front-end operations will be developed to enable the lyses of target cells on slides as well as direct placement into amplification reactions as alternative options to commercial DNA extraction kits. These methods will allow for the direct collection of nuclei, reducing the number of cells required for DNA profiling, and eliminating the DNA extraction step of the overall process. Incorporation of all of the above mentioned LM and FISH procedures would provide alternative methods of sample processing for those labs utilizing LM technologies. Techniques of this nature would also be ideal for labs attempting to process difficult evidence containing low copy number (LCN) cellular mixtures. Once completed, the results will be thoroughly disseminated throughout the forensic community.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K255

University of Central Florida

"Identification of Forensically Relevant Fluids and Tissues by Small RNA Profiling"

Principal Investigator:

Dr. Jack Ballantyne
jballant@mail.ucf.edu

Funding Amount:

$328,962 for 2 years

Abstract:

The serology-based methods routinely used in forensic casework for the identification of biological fluids are costly in terms of time and sample and have varying degrees of sensitivity and specificity. Recently the use of a molecular genetics based approach using messenger RNA (mRNA) profiling has been proposed to supplant conventional methods for body fluid identification. However, the size of the amplification products used in these mRNA assays (~100-250 nt) may not be ideal for use with degraded or compromised samples frequently encountered in forensic casework. Recently, there has been an explosion of interest in a novel class of small non-coding RNAs, microRNAs (~20-25 bases in length), with numerous published studies reporting that some miRNAs are expressed in a tissue specific manner. Additionally, another novel class of small regulatory RNAs, piwi-interacting RNAs (~26-30 bases in length), have been identified only in sperm-producing cells in mammals. It is therefore possible that this class of small RNAs could be ideally suited for the identification of semen. The proposed work seeks to provide a novel strategy for the identification of the body fluid origin of dried forensic biological material (blood, semen, saliva, vaginal secretions, menstrual blood, skin) through expression profiling of body fluid specific small RNAs (miRNAs and piRNAs). Uniquely, such an approach may permit not only a molecular-based approach with a greater specificity than that of conventional methodologies for the identification of forensically relevant biological fluids, but may also provide strategies ideally suited for the analysis of environmentally impacted or degraded samples frequently encountered in forensic casework.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K256

Network Biosystems, Inc

"DNA Analysis of LCN Samples: Towards Fully Integrated STR Profiling"

Principal Investigator:

Dr. Eugene Tan
Eugene.Tan@netbio.com

Funding Amount:

$496,991 for 1 year

Abstract:

The goal of the proposed research is to adapt a rapid, fully integrated microfluidic sample-in to results-out system in development to allow Low Copy Number (LCN) DNA profiling. LCN profiling has the potential to be applied broadly to investigations of both violent and property crimes. However, the labor, time, and expense required to generate LCN profiles are even greater than those for conventional forensic samples, and the possibility of artifacts in the resulting profiles is significant. Accordingly, the impact of LCN profiling is much less than it might otherwise be, and the forensic community has yet to fully embrace LCN technology. A fully integrated, microfluidic sample-in to results-out STR profiling system has the potential to address these problems by improving both the throughput and quality of LCN profiles.

Network Biosystems (NetBio) is developing a fully integrated, microfluidic sample-in to results-out STR profiling system (Figure 1) that consists of three basic modules: i) DNA extraction, purification, and human specific quantitation; ii) highly multiplexed amplification; and iii) separation and detection of the resulting STR fragments. The instrument is designed to generate full STR profiles in 45 minutes and to be utilized by a non-technical operator. The system consists of three components:

- The Smart Cartridge (SC) accepts a forensic sample for analysis (e.g., swab) and extracts and purifies DNA in a volume of 10 µl. The SC contains all required reagents onboard.
- The Integrated Biochip (IB) accepts the purified DNA solution and performs highly multiplexed amplification of all CODIS loci and electrophoretic separation by laser-induced fluorescence detection. The IB contains all required reagents onboard.
- The fully integrated instrument accepts the SC and IB, and performs all required manipulations.

Over the past five years, NetBio has completed much of the development of the individual components of the system and is currently focused on developing a microfluidic human specific quantitation module (supported by NIJ 2008-DN-BX-K009), an optimized SC (the initial SC was completed with support from NIJ 2007-DN-BX-K184 and current work is supported by NIJ 2008-DN-BX-K010), and integrating the components of the system into a single instrument.

The goal of the proposed research is to modify the PCR and separation and detection modules to allow LCN profiling using the integrated system:

- A microfluidic post-PCR cleanup module will be developed, optimized, and integrated with the PCR amplification module to enhance signal strength from LCN samples. The injection efficiency of Genebench FXTM, the separation and detection component, will be optimized by modifying injection times and voltages to improve signal strength.
- The PCR amplification module will be optimized for high sensitivity and enhanced limit of detection.
- The optimized system components will be tested using mock LCN casework samples and laser capture microdissected samples in collaboration with Bode Technology Group (BTG). NetBio has also initiated the modification of the Smart Cartridge to enhance collection, extraction, and purification efficiency of LCN samples.

The ultimate result of the proposed research will be a system that will generate an STR profile in approximately 50 minutes from LCN sample introduction with minimal operating requirements (approximately 5 minutes longer than the target time for the standard system due to the addition of the post-PCR clean-up module). The integrated instrument will allow routine generation of full profiles from LCN samples containing 30 pg of genomic DNA (the amount of DNA contained in approximately five human cells) and partial profiles from samples containing from 6 to 30 pg. Furthermore, the profiles will have fewer artifacts than those generated by conventional LCN analyses.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-DN-BX-K260

Arryx, Inc

"Development of an Automated Holographic Optical Trapping Method for Rape Kit Analysis"

Principal Investigator:

Dr. Tania Chakrabarty
tchakrabarty@arryx.com

Funding Amount:

$362,800 for 1 year

Abstract:

Optical trapping is a well established scientific technique which has been widely applied in cell biology to manipulate cells. It is a non-destructive method where trapped cells can live and reproduce while being held in the traps for extended periods. Arryx has developed a robust commercial research instrument which can simultaneously deploy and move multiple optical traps independently of each other in three dimensions, employing the unique and patented Holographic Optical Trapping (HOT) technique. This technology could provide an automated and precise means for separating spermatozoa from epithelial cells in sexual assault samples. Moreover this technology enables the isolation of individual cells, opening the door to new techniques for single-cell analysis. Recent work at Arryx has demonstrated the compatibility of optically trapped sperm with downstream PCR and STR analysis and the feasibility of HOT-based cell isolation occurring in an automated fashion with an attractive total processing time. Arryx has also recently developed some of the key software, instrumentation, and sample-handling capabilities required for the creation of a robust, automated processing system. We propose to develop a prototype system for the automated isolation of sperm cells from epithelial cells in sexual assault forensic samples. This system promises significant advantages over standard techniques such as differential extraction, offering improved speed, efficiency, automation, genetic purity, and reliability. Importantly, it will dramatically reduce or eliminate female DNA carryover which occurs with current methods. Additionally, this technology offers benefits over some of the proposed alternate techniques such as laser capture microdissection (LCM), magnetic bead based separation and Y-STR. This work specifically addresses the priority areas of the Forensic DNA Research and Development solicitation in that it provides the capability to physically separate the mixed components in a forensic sample, reduce the manual labor of processing, and produce more robust and informative DNA analysis of forensic samples.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2009-IJ-CX-0021

University of Connecticut

"Exploring the Genetic Diversity of Bacterial Populations in Soil for Forensic Applications"

Principal Investigator:

Dr. Linda Strausbaugh
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Funding Amount:

$20,000 for 1 year

Abstract:

In the rapidly evolving field of forensic science, the discovery, application, and validation of new genetic techniques is crucial. During the past decade, the focus of such advancements has broadened to include non-human platforms. When soil evidence was first included in forensic investigations, its discriminatory power was narrow. Physical classification of soil was limited to subjective characterization. As technology progressed, molecular techniques provided a more comprehensive method for studying soil ecology using a metagenomics approach. Bacterial community diversity quickly became the target of many basic research efforts. Currently, there are a handful of techniques that are predominantly used to generate bacterial profiles from soil. Terminal Restriction Fragment Length Polymorphism analysis (T-RFLP) is the most widely used method for studying community structure in non-forensic contexts. For this reason, T-RFLP was chosen as a candidate method for generating forensically relevant bacterial profiles from soil.

In 2002, Horswell et al. demonstrated that T-RFLP was successful in generating bacterial profiles that not only exploited diversity, but were also reproducible. In 2008, Meyers et al. further examined the potential use of soil as forensic evidence by addressing the effects that seasonal and spatial variation had on the ability to conclusively match samples together. However, the exact limitations of forensic soil analysis are still under debate.

The research described in this narrative aims to bridge the gap between basic soil research and successful application of forensic soil typing techniques. First, a novel universal bacterial typing method utilizing fragment analysis on an HPLC platform has been developed in order to determine whether a different way of representing bacterial community diversity can be more informative as compared to T-RFLP profiling. While DNA profiles from soil were achieved using the HPLC platform, when compared to T-RFLP, both methods were equally informative, and thus had comparable discriminatory capabilities.

The profiling data generated from universal bacterial typing suggested that the collective detection of bacteria in soil yielded profiles that were too general. The second goal of our research is to examine the potential for species-specific detection of bacteria, ultimately developing a multiplex typing kit for soil.

By utilizing 454 GS FLX pyrosequencing data, a detailed collection of the bacterial phyla present in soil can be generated. From this extensive list, bacterial groups can be identified as "signature" organisms, thus creating a list of potential species-specific targets for molecular analysis. Preliminary pyrosequence data has been generated from 4 diverse habitats. Classification of bacterial sequences reveals several phyla that vary quantitatively and qualitatively among these samples. Pyroseqencing will be performed on environmental replicate lawn habitats in order to expand the list of potential signature organisms. In studying soils from environmental replicate lawn habitats, we will also be able to determine whether a particular bacterial signature can be identified for this habitat.

There is great need for a forensically relevant, comprehensive soil typing kit that can be put into practice in the forensic community. Since a majority of crimes are committed outdoors, soil evidence can provide valuable information as associative evidence. Particularly when investigators believe a crime scene encompasses multiple locations. A multiplex kit would provide uniformity to the typing process, therefore increasing the reliability of the DNA profile in court. This research also further examines the limitations of soil analysis, such that data interpretation is not overreached.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

FY 2010 Forensic Science R&D Solicitations and Awards

In FY 2010, there were a total of five (5) research and development solicitations released by NIJ on behalf of the General Forensics R&D, Fundamental Forensic Science Research, and Forensic DNA R&D Programs. These include:

- "Research and Development on Forensic Crime Scene and Medicolegal Death Investigations"
- "Research and Development on Pattern and Impression Evidence"
- "Research and Development on Instrumental Analysis for Forensic Science Applications"
- "Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines"
- "Forensic DNA Research and Development"

Of these five solicitations, a total of sixty-six (66) awards were made by the NIJ to the amount of $26,753,937.

#1. Research and Development on Forensic Crime Scene and Medicolegal Death Investigations

Posting Date: December 30, 2009

Closing Date: March 2, 2010

Awards Made: 7

With this solicitation, NIJ sought proposals for research and development to enhance forensic crime scene examinations and forensic medicolegal investigations of death. Specifically, this solicitation focused on:

- New or improved forensic tools and technologies that will allow for the detection and identification of evidence at a crime scene; e.g., latent prints, blood spatter, blood, semen, hairs, fibers, gunshot residue, explosive residue, fire debris, and impression evidence – including:
  - Smaller, more rugged, and less labor-intensive non-destructive analytical tools and technologies for the onsite presumptive and/or confirmatory analysis of forensic evidence at a crime scene.
  - Improved means to locate, identify, capture, and stabilize samples (kit development), which are applicable to trace particulate, liquid, chemical, and biological evidence, and which provide immediate partitioning of samples for secondary testing.
  - Improved means to remotely detect forensic evidence at a crime scene to overcome scene hazards and prevent evidence contamination.

- New and improved forensic tools, technologies, or methods to aid in crime scene reconstruction to better examine, illustrate, and document a scene.
- Forensic tools and technologies to assist the forensic pathologist and medicolegal death investigator in determining the cause and manner of death.
- Research and development into the use of forensic virtual autopsy as a tool in postmortem examination, whether used in concert with standard gross autopsy, or as a stand-alone tool, to execute a thorough post-mortem examination.
- Studies in forensic taphonomy and postmortem interval to better estimate time since death.
- Research in forensic pathology, specifically including research into the cause and manner of suspicious pediatric deaths.
- Forensic studies on the physics of wounding as related to trauma analysis, to assist in the determination of cause of death.
- Updated forensic morphometric standards to better assess the biological profile of unidentified human remains to assist in the identification of those remains.

FY 2010 Crime Scene and Medicolegal Death Investigation R&D Awards

Grant Number	Grantee	Title	Page #
2010-DN-BX-K194	Harris County	Novel Computer-Assisted Identification Method Using Radiograph Comparison	Pg. 84
2010-DN-BX-K144	Teledyne Scientific and Imaging, LLC	Day and Night Real Time Signature Enhanced Crime Scene Survey Camera	Pg. 86
2010-DN-BX-K205	Regents of the University of New Mexico	Utility of Postmortem X-ray Computed Tomography (CT) in Supplanting or Supplementing Medicolegal Autopsies	Pg. 88
2010-DN-BX-K180	West Virginia University Research Corporation	Estimating Postmortem Interval: A Molecular Approach	Pg. 90
2010-DN-BX-K231	Board of Regents, University of Nebraska-Lincoln	Establishing Blow Fly Development and Sampling Procedures to Estimate Postmortem Intervals	Pg. 92
2010-DN-BX-K036	The Trustees of Indiana University	Development of a Sampling System to Stabilize Ignitable Liquid Residues in Fire Debris	Pg. 94
2010-DN-BX-K035	New York City Office of Chief Medical Examiner	Estimation of Age at Death using Cortical Bone Histomorphometry	Pg. 96

2010-DN-BX-K194

Harris County

"Novel Computer-Assisted Identification Method Using Radiograph Comparison"

Principal Investigator:

Dr. Sharon Derrick
sharon.derrick@meo.hctx.net

Funding Amount:

$366,561 for 2.5 years

Abstract:

The purpose of the proposed digital radiograph identification project is to modify existing technology (QMATM software) to develop a statistically robust method of radiographic identification that meets federal guidelines of admissibility and is accessible, time-sensitive and cost-effective for routine use in medical examiner/coroner offices. Evidentiary standards for forensic evidence, including medicolegal decedent identifications, have changed in the era of Daubert v. Dow Pharmaceuticals.1-4 Rule 702 of the Forensic Rules of Evidence requires that a scientific technique or method not be considered admissible unless it is "the product of reliable principals and methods." 5-6 The assumption is that the technique must have a firm basis in the scientific method, e.g., be replicable, peer reviewed, and supported by calculated reliability and error estimates. DNA profile comparison is the gold standard among medicolegal identification methods largely due to the ability of the method to generate a reliable mathematical probability of the putative identification. The use of traditional identification methods and the development of new methodologies must take the strengthened rules of admissibility into account.

According to the 2004 Bureau of Justice Statistics, medical examiners/coroners in the United States process approximately 4,400 unidentified human decedents a year.7 In practice at medical examiner/coroner offices, DNA profile analysis, which is costly and historically has a turnaround time measured in months, is usually the option of last resort. Methods that return a result more quickly or that cost less are typically the first resources explored for identification. Fingerprint comparison, dental charting and comparison, and anthropologic radiograph comparison are common methods. Similar to the dental examination, antemortem to postmortem skeletal radiograph comparison is based on the analyst's visualization of consistency or inconsistency in specific skeletal features and is heavily dependent on the perceived individuality of the feature, lack of distortion of the view, and the experience level of the anthropologist. Much of the current anthropological research in radiograph comparison focuses on attempts to test and quantify the method, concentrating on uniqueness of specific features in an arbitrarily defined "missing person population" and calculating the probability that presence/absence of a skeletal trait or a visualized shape match supports the identification.

The proposed project is novel because it is based on computer-assisted algorithmic matching of multiple specific anatomical features imaged in standard radiographs. Analyst subjectivity is removed and the

resulting match or non-match is supported by a statistically validated error rate. QMATM software created by Medical Metrics, Incorporated is already validated for computer-assisted matching of anatomical features between multiple radiographic images for diagnosis and treatment of spinal injuries.14-17 During the initial phase of this project QMATM is modified to produce a quantitative score for these shape matches.

Approximately 19,600 anterior-posterior and lateral images of commonly imaged anatomical regions are used for individual testing with the forensic version of QMATM. The calculated match scores are analyzed to determine the score threshold that optimally differentiates between correct and incorrect matches. The probability of an erroneous match above the identified threshold is determined. The sample is diverse in age range and temporal interval between the radiographic evaluations, and the effects of these variables on match score and error are measured.

A future multi-center prospective study is planned after the results of the current project are disseminated. The future project is designed to test the ability of individual medical examiner/coroner offices to use the forensic version of QMATM during practical application of the method in routine medicolegal identification casework.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K144

Teledyne Scientific and Imaging, LLC

"Day and Night Real Time Signature Enhanced Crime Scene Survey Camera"

Principal Investigator:

Dr. Milind Mahajan
mmahajan@teledyne.com

Funding Amount:

$439,518 for 2 years

Abstract:

Teledyne Scientific & Imaging (TS&I) is pleased to submit a proposal for a two year (two phases- total $865,079) effort to develop and demonstrate a novel forensic camera in response to solicitation SL000925. We recommend a third year (ROM $450K) technology transition option to develop a commercial product to be formally proposed during Phase 2.

The proposed camera will collect and process multi-spectral (UV-visible-NIR), dual polarization, and fluorescence images of the scene to enhance identification of body fluids, stains, other residues, and fingerprints in real time and in presence of sunlight. This revolutionary camera system will enable previously unrealized flexibility, automation, and efficiency in surveying a crime scene.

Contrast enhancement techniques that use alternate light sources (ALS) with multiple wavelength filters, off-axis illumination for prints, and fluorescence imaging for bio-fluids, are powerful tools already in use by the forensic community. However all of these techniques require a darkened environment, limiting the utility of those visualization methods and posing significant logistical challenges. We will develop and demonstrate a new integrated sensor approach that uses a combination of a narrowband agile (tunable) wavelength filter, a pulsed light emitting diode (LED) illuminator synchronized with camera exposure, and real time background subtraction to suppress background even in direct day light for ranges up to 15 feet (5 m) from the crime scene (and significantly more in indirect sunlight). Furthermore a single affordable integrated solution that performs collection and analysis to identify the optimum contrast channels, and subsequently renders a false color map of the desired targets overlaid on the scene image is technically feasible and will be realized in this program. TS&I has extensive relevant experience in each of the technologies to be integrated into such a camera system.

During the first phase (1 year, $412,233), we will integrate commercial-off-the-shelf (COTS) components on a compact (12"×24") optical bench to achieve a breadboard prototype. The breadboard prototype will be employed in a trade study using simulated crime scene problems with a variety of targets (with clutter). The data will be used to refine the proposed design, and optimize the image processing/rendering algorithms. Phase 1 will conclude with a review, laboratory hardware demonstration, and a report of the findings, including recommendations for a brassboard device to be

built in the Phase 2 (1 year, $452,845). A compact, rugged Phase 2 brassboard will be provided to a forensic laboratory for field evaluation.

Continuous feedback from the end-user community throughout the research and development effort is critical to the success of the project. We will engage local crime scene experts to draft preliminary specifications, create test scenarios, and to provide operational feedback for the Phase 1 trade study. In the second phase, their role will include operational and ergonomic feedback for the planned brassboard development. Our team approach and complementary capabilities between various team members is shown in Figure 2. Our two-year R&D effort will establish a technology transition path to a commercial product within the Teledyne group of companies. Our parent company Teledyne Technologies, Inc. has an extensive track record in instrumentation products including several used by forensic laboratories.

We believe that the proposed effort offers significant improvements to crime scene evidence detection and identification and are confident that we can establish a viable path to providing a revolutionary next-generation forensic tool at a reasonable cost and schedule to the forensic investigation community.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K205

Regents of the University of New Mexico

"Utility of Postmortem X-ray Computed Tomography (CT) in Supplanting or Supplementing Medicolegal Autopsies"

Principal Investigator:

Dr. Kurt Nolte
knolte@salud.unm.edu

Funding Amount:

$895,832 for 3 years

Abstract:

The utility of computed tomography (CT) in the practice of forensic pathology has not been clearly defined. A variety of case studies and case series have indicated potential areas of use such as trauma (firearm, blunt force, drowning, burns, strangulation) foreign body discovery, mass fatality processing and body identification. However, systematic studies have been few. There has been inconsistent evidence of the utility of CT as a substitute for autopsy in cases of fatal trauma. Some studies have shown that there are injuries seen by CT that are not detected by autopsy indicating that CT is likely useful as an autopsy adjunct. The previously performed studies have been limited by small study populations, large variation in postmortem interval, differences in study protocols including a wide range of slice thickness, differences in who interpreted the scans (radiologists vs. pathologists), and how injuries were scored.

Over 3 years, we propose to use a large centralized statewide medical examiner office that serves a population of 2 million and performs 2100 autopsies per year to prospectively evaluate 4 potential situations where CT might supplant or supplement forensic autopsy. We will evaluate common unnatural death subsets (blunt force injuries, firearm deaths and poisoning deaths) and the less common subset of traumatic deaths in children 5 years of age and younger using a Philips Brilliance Big Bore 16 slice CT scanner. Our specific questions are:

1. Blunt Force Injuries: Can a postmortem CT scan supplant autopsy in recognizing fatal blunt force injuries and identifying the cause of death? If not, does postmortem CT recognize sufficient injuries not recognized by autopsy to justify its utility as a supplemental procedure?
2. Firearm Injuries: Can a postmortem CT scan supplant autopsy in recognizing fatal gunshot wound tracks and trajectories? If not, does postmortem CT recognize sufficient gunshot injuries not recognized by autopsy to justify its supplemental utility?
3. Potential Drug Poisoning Deaths: In potential cases of drug poisoning, will the combination of external body examination + postmortem CT scan + toxicologic evaluation recognize enough underlying natural disease and traumatic injuries to supplant autopsy + toxicologic evaluation in correctly identifying the cause of death?

4. Childhood traumatic fatalities: Does the combination of autopsy + CT scan supplement the injuries identified by the present practice of autopsy + x-ray in childhood injury deaths? Does the addition of CT to the standard practice of autopsy + x-ray in childhood injury deaths change the cause of death determination?

We will evaluate fatal cases of blunt trauma (200), firearm injuries (200), drug poisoning (460), and childhood traumatic injuries (76). Blinded board certified radiologists will interpret CT images. Corresponding autopsies will performed by blinded board certified forensic pathologists. Both radiologists and study pathologists will use the abbreviated injury scale to score injuries and an organ-based system to score diseases. Data will be entered into a REDCap database and will be analyzed using SAS version 9.2.

If CT is found to supplant or supplement autopsy in valuable ways, law enforcement officials and those engaged in the criminal justice process will have more comprehensive information about these deaths. If CT can supplant the use of autopsy in certain situations and allow medicolegal jurisdictions to significantly decrease the number of autopsies performed it will allow offices to achieve an annual cost savings and divert these resources to other needs. If CT becomes more widely available to supplant autopsy in medical examiner and coroner offices it could make up some of the gap between the numbers of forensic pathologists available and the numbers of forensic pathologists needed nationally.

The total budget for this 3-year project is $1,067,128.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K180

West Virginia University Research Corporation

"Estimating Postmortem Interval: A Molecular Approach"

Principal Investigator:

Dr. Clifton Bishop
cbishop@mail.wvu.edu

Funding Amount:

$462,492 for 2 years

Abstract:

The accurate determination of time since death, or the postmortem interval (PMI), can be critical in the investigation of suspicious deaths. Knowing when a suspicious death occurred can limit the number of potential suspects to those without a viable alibi for the time of the crime. The forensic techniques currently employed to determine PMI, with the exception of forensic entomology, are accurate in their estimations only for a period of approximately four days following death. Forensic entomology can provide PMI estimates over longer time periods, but this requires expert knowledge of local insect life cycles. This is not always available. We are currently developing a technique, using well established molecular biology methods to estimate PMI. Our approach is akin to the dating techniques used in archeology, in which the time-dependent ratio of an unstable isotope (Carbon 14) to a stable one (Carbon 12) permits estimates of the age of a carbon-based object of interest. The half-life of Carbon 14 is over 5,000 years, making it impractical for forensic science purposes. However, we have shown that certain biological species of Ribonucleic Acid (RNA) degrade at different rates in a time dependent fashion. The differences in decay rates of different species of RNA become detectable after the death of an individual. This time-dependent change in the ratio of the selected RNA-species enables us to estimate PMI. Our pilot study utilized eight pig heads as a model system for deceased humans. The RNA studied was recovered from the soft tissue found inside teeth (dental pulp). The tooth's hard enamel protects the dental pulp from most environmental factors such as humidity and foraging insects or other biological agents that might alter the rate of RNA degradation. The pig heads were buried in shallow graves and teeth were extracted on predetermined days from day 0 to day 140. The pulp from each tooth was harvested and RNA ratios determined using the molecular method of reverse-transcription Real-Time PCR. Our results indicate that this technique, coupled with a colorimetric analysis of the pulp, can be used to determine PMI over a period of 84 days. This compares favorably to insect data that were gone by 28 days postmortem. Eighty-four days appears to represent a maximum time period for which data from our targeted RNA could be recovered. We are confident that analysis of additional RNAs will enable us to provide more precise estimates of PMI over longer periods of time. We propose to expand our studies on pigs' teeth and to extend these studies to human teeth as well. At the end of our proposed two-years of research, we anticipate providing the forensic science community with a set of protocols and reagents that will permit accurate estimates of PMI beyond the timeframe that is

currently possible. Our overall goal is to develop a reliable, accepted means for estimating time since death that could be applied to specimens collected anywhere in the world. Our success is expected to have the following advantages over existing forensic techniques: there would be no geographical restrictions, it could be utilized absent insect colonization of corpses (for examples, in regions of extreme heat or cold, and when insect access is denied or delayed, such as when bodies are deposited in closed buildings, cars, or in body bags), it would permit a longer time frame over which estimates can be made, no extensive training on the part of the crime scene investigator would be required beyond a limited special training for laboratory personnel, and it would be more economical.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K231

Board of Regents, University of Nebraska-Lincoln

"Establishing Blow Fly Development and Sampling Procedures to Estimate Postmortem Intervals"

Principal Investigator:

Dr. Leon Higley
lhigley@unl.edu

Funding Amount:

$483,323 for 3 years

Abstract:

Because insects are one of the primary agents of animal decomposition, insects routinely provide some of the best biological information available for determining the PMI. Although the process of human decomposition and the forensic importance of blow flies in this process have been recognized for over 1000 years, the benchmark data necessary to relate insect development to the postmortem interval still does not exist. Unfortunately, in the absence of definitive, modern developmental models for all key forensic blow flies, forensic taphonomists must specify large intervals (typically days) in their PMI estimates, they cannot specify descrete levels of probability for their PMI estimates, experts disagree on PMI estimates (because different developmental models or data are used), and PMI estimates are not possible for species having little or no developmental data. Moreover, the current methods recommended for collecting blow flies larvae (maggots) from bodies are not scientifically justified based on research to guarantee that samples reflect the larval population age structure within a specified error rate. Consequently, we proposed developing curvilinear temperature models for key forensic blow fly species of the U.S. (Calliphora vicina, Chrysomya rufifacies, Cochliomyia macellaria, Lucilia sericata, and Phormia regina) to allow estimation of a PMI with a statistically sound measure of variability and to develop blow fly larval sampling procedures for use with specified levels of accuracy and precision. We will validate models developed with field tests and with known time of death cases, and we will develop larval sampling procedures to provide accurate estimates of larval age structure within statistically valid limits. We will implement these models through spreadsheets and other software to allow determining a PMI from maggot development with a calculated level of variation. Finally, we will develop maggot sampling procedures for crime scene investigators that ensure a specified level of statistical accuracy. We believe the research proposed here is essential for improving the quality and rigor of PMI estimates in decomposition cases. With standard development data for key forensically important blow fly species, we can both improve the accuracy of PMI estimates and standardize data sources and methods used by experts. Additionally, having statistically sound sampling methods will further improve the accuracy of estimates and avoid issues about the scientific legitimacy of samples. Because differences in insect development calculations are at the heart of expert differences in PMI estimates, obtaining comprehensive development data and incorporating this into modern, curvilinear development models should provide an indisputable basis for making PMI estimates from insects. Moreover, given that

insects are associated with most decomposition cases, standardizing methods should lead to much greater use of insect data in such cases.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K036

The Trustees of Indiana University

"Development of a Sampling System to Stabilize Ignitable Liquid Residues in Fire Debris"

Principal Investigator:

Dr. John Goodpaster
goodpaster@chem.iupui.edu

Funding Amount:

$239,025 for 2 years

Abstract:

Ignitable liquids and their combustion residues that are found in soils or similar materials are susceptible to microbiological attack following sample collection at a fire scene. The fact that microorganisms can metabolize components of petroleum is a well-known phenomenon to chemists responsible for analyzing fire debris. Unfortunately, the turnaround time for a fire debris case is typically more than sufficient for significant and irreversible microbial decomposition of ignitable liquid residues to occur under the right conditions. If allowed to progress unchecked, microbial degradation can eliminate the vast majority of compounds that constitute an ignitable liquid residue and ultimately lead to inconclusive or even false negative findings in fire debris cases.

Two approaches will be pursued to avoid microbial degradation of ignitable liquid residues. The first is to inhibit or eliminate the microbes naturally present in soil and debris. While some laboratories refrigerate fire debris to minimize bacterial attack, this technique is expensive, space consuming and of mixed effectiveness. This project will develop a practical and effective preservative that can be used by investigators in the field to stabilize fire debris evidence. Anti-microbial agents of interest include broad-based chemical treatments, more selective antibiotics as well as introducing bacteriovores into soil samples. Any proposed solution will be non-volatile, non-corrosive and safely deployable by investigators.

The second approach involves a sampling container that could immediately partition ignitable liquid residues from fire debris. This container will adapt passive adsorption methods that can immediately extract ignitable liquid residues from fire debris upon collection at a fire scene. Such a container would increase the recovery of ignitable liquids from any matrix and also help to avoid any degradation that may occur within the soils. Adsorbent materials that will be evaluated include activated charcoal strips, SPME fibers and coated stir bars. In each case, the adsorbent material will not be in physical contact with the debris.

The effectiveness of each preservative will be evaluated using microbiological techniques, in collaboration with experts in the areas of soil science, biology and biochemistry. In addition, testing of realistic soils and fire debris using ASTM methods will verify that ignitable liquid residues are being

effectively preserved for periods of up to 30 days. Overall, the proposed innovations will result in increased sample integrity and a vastly improved ability to accurately identify an ignitable liquid in fire debris. Inconclusive or false negative results will be reduced and the overall reliability of the analysis will be increased.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K035

New York City Office of Chief Medical Examiner

"Estimation of Age at Death Using Cortical Bone Histomorphometry"

Principal Investigator:

Dr. Christian Crowder
ccrowder@ocme.nyc.gov

Funding Amount:

$114,263 for 1.5 years

Abstract:

Estimating the age at death in the adult skeleton is problematic owing to the biological variability in morphological age indictors and the differential skeletal response to environmental factors over an individual's life. It is becoming increasingly important for anthropologists to improve age estimates through the use of multiple age indicators and various modalities of assessment (e.g., macroscopic and microscopic). Degenerative changes to the adult skeleton, which are the basis of the gross morphological assessment of age, do not demonstrate a strong linear relationship with chronological age. It has been argued that quantitative cortical bone histology, or histomorphometry, provides an approach to adult age estimation that is more accurate, less subjective, and has the potential to bridge the 50+ age boundary where gross methods fail to provide accurate age estimates; yet histological methods are still not widely applied in forensic anthropology.

Unlike gross morphological age estimation, histological age estimation is not based on degenerative changes to the skeleton. Histological methods are based on the continuous turnover or replacement of primary cortical bone with secondary cortical bone, which occurs at a more predictable rate. The avoidance of histological methods is likely due to a scientific literature that is confusing, inconsistent and sometimes conflicting in terms of recommended methodology and reported rates of precision and accuracy. The goal of this research is to produce a new histological method of age estimation that addresses the past methodological problems rather than reproducing them in a revision of a previously developed method. Furthermore, an objective of this research is to determine the practical application of histological age estimation utilizing the femur by revealing the biological limitations of bone turnover as an age indicator through the evaluation of the large reference sample proposed for this research.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

#2. Research and Development on Pattern and Impression Evidence

Posting Date: December 30, 2009

Closing Date: March 2, 2010

Awards Made: 8

With this solicitation, NIJ sought proposals for research and development to enhance the ability of forensic scientists to identify, capture, visualize, analyze, and preserve impression evidence and pattern evidence. Specifically, this solicitation focused on:

- Tools and methods that will allow faster, more widely applicable, more rugged, less costly, or less labor-intensive identification, collection, preservation, and analysis of impression and pattern evidence at the crime scene or in the forensic laboratory, such as tools or methods to collect and preserve various forms of perishable impression evidence.
- Studies in fluid transfer and fluid dynamics, specifically blood, to analyze bloodstain patterns to assist in the reconstruction of a crime.
- Studies to examine the mechanical properties of materials (fracture mechanics) in physical match analysis of evidence.
- Research on the effect of environmental factors on impression and/or pattern evidence; i.e., factors that compromise class or individual characteristics of impression and/or pattern evidence, and methods to overcome the deleterious effects.

FY 2010 Pattern and Impression Evidence R&D Awards

Grant Number	Grantee	Title	Page #
2010-DN-BX-K232	The Pennsylvania State University	Acquisition of Fingerprint Topology using Columnar Thin Films	Pg. 99
2010-DN-BX-K038	County of Ventura	Research and Development on Pattern and Impression Evidence - Evaluating high dynamic range (HDR) processing with regards to the presence of individualizing characteristics in shoeprint/tireprint impressions.	Pg. 101
2010-DN-BX-K145	Indiana University	Digitizing Device to Capture Track Impressions	Pg. 103
2010-DN-BX-K037	Research Foundation of SUNY	Statistical Examination of handwriting Characteristics Using Automated Tools	Pg. 104
2010-DN-BX-K203	The Trustees of Columbia University in the City of New York	Development of a Science Base and Open Source Software for Bloodstain Pattern Analysis	Pg. 105
2010-DN-BX-K202	The University of Tennessee	Developing Methods to Improve the Quality and Efficiency of Latent Fingermark Development by Superglue Fuming	Pg. 107
2010-DN-BX-K039	University of California at Davis	Quantitative Analysis of High Velocity Bloodstain Patterns: A Double Blind Investigation of Impact Velocity Assessment	Pg. 108
2009-DN-R-119	Ames Laboratory	Significance of Association in Tool Mark Characterization	Pg. 109

2010-DN-BX-K232

The Pennsylvania State University

"Acquisition of Fingerprint Topology using Columnar Thin Films"

Principal Investigator:

Dr. Robert Shaler (ret.)
rcs26@psu.edu

Dr. Akhlesh Lakhtakia
akhlesh@psu.edu

Funding Amount:

$470,216 for 2 years

Abstract:

While most on-scene and in-laboratory fingerprint development applications employ either physical, e.g., powder dusting, or chemical techniques, none have explored the texture of the fingerprint topology as a development method. As prints age or are exposed to environmental stress, the chemistry and some of the physical properties, e.g., drying, the friction ridge detail, in essence the print residue, becomes progressively more difficult to develop. While it is as yet completely unknown for all possible environments in which fingerprints are found, it is expected that even though the chemical and physical properties of fingerprint residue may become progressively more difficult to analyze, the texture or topology of the print may remain. In that regard, the purpose of this research is to investigate the application of the solid-state acquisition of friction ridge surface texture (topology) of forensically relevant surfaces using columnar thin films (CTF) and to ascertain how common environmental stresses - temperature, humidity, sunlight, and age - affect CTF prints as compared to traditionally developed fingerprints.

This research focuses on the friction ridge detail of fingerprints found on forensically relevant surfaces for which common development techniques, chemical and physical, are either inapplicable or not ideal. During CTF deposition, a dense array of nanoscale columns is deposited over the fingerprint which copies its surface, the sole requirement being a texture different than the underlying substrate (surface). Generally, fingerprints meet this requirement, and the resulting CTF print can be visualized using the usual optical techniques. The concept is similar to a child's toy called the Round Pin Point, Figure 1. When the pins stand over an undulating surface, the top surface also undulates mimicking those of the bottom surface. Preliminary proof-of-concept experiments (Figures 2-4) have been completed. The proposed research will be conducted in continuously overlapping phases. In Phase I, the work will investigate CTF deposition materials (evaporants) in order to identify an optimum or the most appropriate fingerprint CTF acquisition material for different surfaces. Next, the growth process and characteristics of the evaporant on fingerprint emulsion will be studied, along with the selection of an ideal level of vacuum, the direction of vapor flux (angle of deposition), and the spatial requirements needed for curved surfaces.

In Phase II, fingerprints on various surfaces will be exposed to environmental stresses – heat, humidity, sunlight (UV light), and ageing, for up to one year. Surfaces selected will be forensically relevant and for which common development techniques are either inadequate or not ideal. Nine nonporous and porous surfaces have been selected from categories that include plastics, adhesives, paper and metals as well as partial bloody prints.

In Phase III, duplicate prints on the environmentally exposed surface will be developed using the CTF parameters developed in Phase I and by traditional development techniques commonly employed for that surface. Both developed prints will be compared and graded according to quality. Grading will be accomplished by segregating prints subjectively into categories pre-defined by their clarity and extent of development: poor, medium, good, excellent. Prints placed into each category will be re-examined and photographed. The prints in the top two categories will be ranked using a more objective mechanism, such as that suggested by Humphries (1).

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K038

County of Ventura

"Research and Development on Pattern and Impression Evidence – Evaluating high dynamic range (HDR) processing with regards to the presence of individualizing characteristics in shoeprint/tireprint impressions"

Principal Investigator:

Ms. Kristin Rogahn
Kristin.rogahn@mail.co.ventura.ca.us

Funding Amount:

$32,696 for 1.5 years

Abstract:

Challenging photography due to difficult lighting situations is standard at every crime scene. It is imperative that the photographer is able to accurately document the details of a crime despite the vast gaps in stop differences between the brightest areas and the darkest shadows. Traditional photography requires that the photographer either choose to adjust for the brightest areas (which in turn reduces the darker areas to shapeless shadows without detail), or to compensate for the darkness by overexposing bright lights at the risk of losing true color and detail. The compromise is to approximate a mid-range photo that at best produces a flat, marginal representation of the true crime scene.

This dilemma is especially true for shoeprint and tire track photography, which poses a similar problem, but on a micro scale. The difference between "including" a suspect's shoeprint at a crime scene and "identifying" the scene shoeprint to the suspect oftentimes relies on the quality and depth of the photograph. By introducing the ability to capture the increased detail of a footwear impression in three dimensions, the likelihood is that an "identification" to a particular shoe should be increased.

High Dynamic Range (HDR) is a method for processing a photograph so that it captures the fullest range of highlights and shadows in the original impression. All camera film and digital sensors have restricted dynamic range; the difference between the whitest white and blackest black on the screen or print is less than real life. HDR is a method used to increase the span between shadows and highlights in an image by taking more than one picture of the same scene -- one shot maximizing shadows, one mid-tones, and one highlights -- and then merging them into one unified picture with tremendous range. Using this technique, the research intends to define whether or not HDR is a valuable tool in terms of applicability and ease-of-use in the field for increasing the ability to capture more true-to-life images of

footwear impressions. HDR imaging of shoeprints will be compared to current standards for digital shoeprint photography in terms of overall appearance of the impression, increased amount of detail captured, accuracy of detail, and possible increased ability to determine individualizing characteristics.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K145

Indiana University

"Digitizing Device to Capture Track Impressions"

Principal Investigator:

Dr. Mihran Tuceryan
tuceryan@iupui.edu

Funding Amount:

$253,120 for 2 years

Abstract:

Using technology originally developed for civic mapping it is possible to develop a device which can be used to capture 3D and color images of tire tracks and footprint impressions. The device will be easy to use, be non-destructive, and save time at crime scenes. Additional devices can be used in the laboratory to create 3D images of suspect tires or shoes. Computer-based pattern matching technology can be used to assist in matching and comparison tasks. The device will be comparable in price to the equipment currently used and will be easy to use with better quality data obtained in the field.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K037

Research Foundation of SUNY

"Statistical Examination of Handwriting Characteristics Using Automated Tools"

Principal Investigator:

Dr. Sargur Srihari
srihari@cedar.buffalo.edu

Funding Amount:

$425,077 for 2 years

Abstract:

The project proposes to provide a statistical basis for reporting the results of handwriting examination by questioned document (QD) examiners. As a facet of QD examination, the analysis and reporting of handwriting examination suffers from the lack of statistical data concerning the frequency of occurrence of combinations of particular handwriting characteristics. QD examiners tend to assign probative values to specific handwriting characteristics and their combinations. However their judgments are often based entirely on the examiner's experience and power of recall. Statistical data concerning frequency of occurrence of forms and combinations would offer promise for providing a scientific basis for their opinions.

The research proposes to use previously created data bases of handwriting samples that are representative of the United States population. Existing feature lists of characteristics for different letter combinations, as well as new ones to be provided by QD examiners, will be used as the basis to determine as to what frequencies need to be evaluated. Existing and new algorithms will be used to automatically extract those characteristics from the data base, e.g., a software tool for extracting most of the characteristics from the most common letter pair \th", is already available. For each letter combination the marginal and conditional frequencies of their characteristics will be evaluated. Based on statistical dependencies of the characteristics a method of evaluating the probability of any given letter formation will be given. The resulting algorithms will be incorporated into an existing automatic system for writer verification/identification. Project deliverables include frequency tables, software tools to combine the frequencies into probabilities and the incorporation of the algorithms developed into a previously developed software system for QD examination.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K203

The Trustees of Columbia University in the City of New York

"Development of a Science Base and Open Source Software for Bloodstain Pattern Analysis"

Principal Investigator:

Dr. Daniel Attinger
da2203@columbia.edu

Funding Amount:

$632,244 for 3 years

Abstract:

We propose a fundamental and collaborative research on the fluid dynamics and pattern recognition of bloodstains to help forensic experts better answer the following questions: How was this violent crime committed? What was the sequence of criminal events? When did they occur?

Bloodstains are deterministic signs of a violent crime. Bloodstains are signs that help determine how the crime happened, pointing e.g. to the point of origin of a blood splatter. Also, overlapping or wiped-off bloodstain patterns give information on the timing of the crime. Bloodstain Pattern Analysis is however not straightforward, because the physical relation between blood impact and the resulting bloodstains is non-linear. Indeed, the formation of bloodstains involves a complex fluid (the blood), a subtle interplay of fluid mechanics, heat and mass transfer, in the presence of a deforming free surface, and impact surfaces with varying roughness and wettability. There is therefore a need for a science base of the fluid dynamics and pattern recognition of bloodstains.

Our team at Columbia University brings expertise in fluid mechanics, pattern recognition and open-source software. We will develop a strong collaboration with forensic consultants Herb MacDonell and Bill Fisher. Deliverable of our research will be a fundamental knowledge base, public databases and four pieces of open-source software as described below.

This theoretical, numerical and experimental research involves two phases, each with experimental, theoretical and numerical components. The first phase (year 1) studies individual bloodstains, with experiments involving a range of droplet volumes, impact velocities magnitude and angle wider than in the current literature. Dimensional numbers such as the Reynolds and Weber number will be used to reduce the parameter space and express general laws. Laser scanning methods will be used to measure the three-dimensional bloodstain. Pattern recognition methods will be used to classify bloodstains and infer the impact conditions. Also, a numerical modeling of trajectories of individual droplets will be developed; accounting for gravity and air resistance, and its accuracy will be tested.

In the second phase (year 2,3) we will generate blood splatters with multiple bloodstains, and investigate wipe-off events. An optoprofiler will be acquired to record 3D scans of stained surfaces, with

µm resolution in height. This device quickly scans large areas, and can be used by the investigator in the field. An online public database will be created that shows all the patterns. The numerical activities will develop pattern recognition software to determine the sequence of impacts and events that created a complex bloodstain patterns. The points of origin of the blood splatter will be determined accounting for drag and gravity forces. Comparisons between the points of origin obtained with the method of strings (state of the art), pattern recognition of 2D pictures and pattern recognition of 3D scans (our work) will characterize the improvement in precision. In parallel, we will develop a 3D open source version of the numerical code available in our laboratory, to simulate blood drop impact on various substrates, at various angles, with various drop velocities and sizes. This code will be calibrated from experiments and will predict bloodstain patterns under conditions difficult to control or reproduce experimentally. All the efforts described here will be disseminated via scientific conferences and educational workshops, in active collaboration with forensics consultants.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K202

The University of Tennessee

"Developing Methods to Improve the Quality and Efficiency of Latent Fingermark Development by Superglue Fuming"

Principal Investigator:

Dr. Mark Dadmun
dad@utk.edu

Funding Amount:

$258,816 for 3 years

Abstract:

The proposed research program will provide fundamental information that will enable the straightforward improvement of the superglue fuming method of developing latent fingermarks, by optimizing the acquisition of developed latent fingermarks and enhancing the quality of aged fingermarks. This will be realized by, first, using our expertise in polymer chemistry to explain the role of temperature on the superglue fuming of aged fingermarks. Our preliminary results suggest that fuming at lower temperatures will improve the rate of polymerization that occurs during superglue fuming and thus, provides an easy and cost-effective method to improve the quality of aged prints developed by superglue fuming. Previous results also suggest that rehydration of an aged fingermark is critical to its successful development by superglue fuming, and thus we will investigate aggressive rehydration methods of aged latent fingermarks as a method to improve the quality of aged prints. Additionally, we will understand, with the goal of optimizing, the hardening process of the fumed latent print, a process that is necessary to create a durable print that can be lifted and analyzed. Thus, we propose to complete a series of experiments that will provide fundamental information that can be used by forensic scientists in the field to create protocols to improve the effectiveness and optimize the process of the superglue fuming method to develop, visualize and analyze latent fingermarks.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2010-DN-BX-K039

University of California at Davis

"Quantitative Analysis of High Velocity Bloodstain Patterns: A Double Blind Investigation of Impact Velocity Assessment"

Principal Investigator:

Dr. William Ristenpart
wdristenpart@ucdavis.edu

Funding Amount:

$248,799 for 1.25 years

Abstract:

The goal of this study is to establish statistically significant classifications of blood spatter patterns resulting from the interactions between a weapon, suspect and victim. Specifically, a "medium velocity" spatter pattern is usually attributed to blunt force injury, while a "high velocity" pattern is typically attributed to a gunshot wound. The differentiation between these classifications, however, is often qualitative and controversial. A review of the literature indicates that when the final determination is made, the only statement offered is that a particular spatter pattern is "consistent" with a certain type of wounding event. There are neither supporting statistical data nor are there objective criteria as to what constitutes "consistency" or the associated error rate. In this study, high speed video (at 10,000 frames per second) will be used to visualize simulated bloodshedding events. The impact velocity of various blunt instruments (e.g., hammers, bats, wrenches, etc.) will be varied systematically, as well as the target surface roughness (e.g., cardboard, tile, carpet, etc.) Analogous experiments will also be performed with different caliber bullets fired at systematically varied distances. The spatter drop size distribution and morphology will be digitized and quantified in each case using a series of rigorous metrics, thereby developing a large statistical "library" of spatter patterns. Photographs of the patterns will then be assessed by trained analysts in a double-blind fashion, with the goal of providing quantitative error rates and testing objective criteria for the classification of medium and high velocity bloodstain patterns.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

2009-DN-R-119

Ames Laboratory

"Significance of Association in Tool Mark Characterization"

Principal Investigator:

Dr. Scott Chumbley
chumbley@iastate.edu

Funding Amount:

$390,000 for 2 years

Abstract:

One weakness that currently exists in the field of comparative examination of evidence is the general failure of current approaches to adequately assess the significance of association through quantitative measures that provide a statistical evaluation of evidence. While various efforts have been made and methodologies employed over the years, such as the measurement of consecutive matching striations, tool mark comparisons remain difficult to quantify in terms of a robust statistically valid sense that allows the examiner to assign confidence levels and predict error rates. In a recent study of tool marks produced by sequentially made screwdriver tips, the authors developed a computer algorithm that was able to reliably separate matching tool marks from those that do not match using an analysis based on Mann-Whitney U-statistics applied to data files containing two-dimensional information obtained using an optical profilometer. These successful results indicate that significance of association can be accomplished by statistical evaluation of the data files.

The goal of this proposal is two-fold: 1) to extend the previously developed statistical methodology to allow for self-calibration to control rates of false nonmatches, and 2) empirically validate the methodology developed by performing experiments using two different types of tool marks. Working with a trained forensic examiner, the project will characterize the variability of marks from a single screwdriver tip as a function simply of time and substrate material. This data will be used to establish the variation in U-statistic values inherent in the system (i.e. a single tip) and allow confidence intervals to be assigned denoting significance of association to the comparison statistics generated by the algorithm. This will complete the methodology whereby data files can be compared and matches identified in such a way as to control the probability of a false non-match result. In the second part of the project, this complete methodology will be applied to an entirely new system separate from the screwdriver tool marks employed for the initial study. In this case, markings produced as the bypass

cutting blades of a pair of pliers shear through metal will be analyzed and tested to determine the applicability of the approach. Successful validation of the methodology in this manner will create a wide range of possible future applications for the developed statistical algorithm that could revolutionize comparative tool mark analysis.

NIJ Point-of-Contact

Program Manager: Danielle McLeod-Henning

#3. Research and Development on Instrumental Analysis for Forensic Science Applications

Posting Date: December 30, 2009

Closing Date: March 2, 2010

Awards Made: 12

With this solicitation, NIJ sought proposals for funding research and development of techniques to address the need(s) of State and local forensic science practitioners. Specifically, this solicitation focused on:

- Development of novel analytical techniques to analyze and interpret evidence.
- Improvements in the reliability, reproducibility, selectivity, and/or sensitivity of current methods used in crime laboratories for forensic analysis.
- Instrumental systems to improve analysis throughput.
- Analytical instruments for onsite presumptive and/or confirmatory analysis of evidence. NIJ is particularly interested in small, rugged, and less labor-intensive analytical tools and technologies for forensic practitioners.
- Novel approaches and enhancement of current approaches to interpret data derived from evidence, including assessment of the significance of association. This may include development of databases and/or analyses that provide quantitative measures and statistical evaluation of evidence.

FY 2010 Forensic Science Instrumental Analysis R&D Awards

Grant Number	Grantee	Title	Page #
2010-DN-BX-K178	Kentucky State Police	Raman Spectroscopy with Multi-component Searching for Complex Clandestine Laboratory Sample Analysis	Pg. 114
2010-DN-BX-K177	Research Triangle Institute	"Expansion of a Cheminformatic Database of Spectral Data for Forensic Chemists and Toxicologists"	Pg. 115
2010-DN-BX-K244	Stoney Forensic, Inc	Use of Scanning Electron Microscopy / Energy Dispersive Spectroscopy (SEM/EDS) Methods for the Analysis of Small Particles Adhering to Carpet Fiber Surfaces as a Means to Test Associations of Trace Evidence in a Way that is Independent of Manufactured Characteristics	Pg. 117
2010-DN-BX-K246	Combustion Science & Engineering, Inc	Forensic Investigation Techniques for Inspecting Electrical Conductors Involved in Fire	Pg. 119
2010-DN-BX-K179	Florida International University	LA-ICP-MS and LIBS analysis of paper, inks, soils, cotton and glass	Pg. 121
2010-DN-BX-K201	Las Vegas Metropolitan Police Department	Research and Development on Instrumental Analysis for Forensic Science Applications	Pg. 123
2010-DN-BX-K176	Marquette University-Office of Research & Sponsored Programs	Replication of Know Dental Characteristics in Porcine Skin: Emerging Technologies for the Imaging Specialist	Pg. 125
2010-DN-BX-K236	Microtrace LLC	Fundamentals of Forensic Pigment Identification by Raman micro-spectroscopy: A practical identification guide and spectral library for forensic science laboratories	Pg. 127

2010-DN-BX-K178

Kentucky State Police

"Raman Spectroscopy with Multi-component Searching for Complex Clandestine Laboratory Sample Analysis"

Principal Investigator:

Mr. Jeremy Triplett
jeremy.triplett@ky.gov

Funding Amount:

$118,195 for 1 year

Abstract:

A new software technology that can deconstruct acquired multi-component Raman spectra into the individual contributing Raman spectrum components will be shown to identify pertinent clandestine laboratory reaction constituents in solution. This will expand upon the already established efficiency and safety profile of the Raman spectroscopy technology. Raman spectroscopy has been shown to be a robust method with a wide range of applications particularly relevant to the forensic controlled substance laboratory. While recent advances indicate the usefulness of new deconvolution software for analyzing multi-component samples, currently there have been no documented attempts to apply Raman spectroscopy and the deconvolution software to the analysis of complex clandestine laboratory liquid samples.

Mock case samples from simulated clandestine laboratories will be analyzed. The Raman technology will be shown to be more efficient versus traditional ATR-IR spectroscopy and the multi-component spectral library algorithm shown to be reliable for multi-component clandestine laboratory liquid samples.

NIJ Point-of-Contact

Program Manager: Frances Scott

2010-DN-BX-K177

Research Triangle Institute

"Expansion of a Cheminformatic Database of Spectral Data for Forensic Chemists and Toxicologists"

Principal Investigator:

Dr. Peter Stout
pstout@rti.org

Funding Amount:

$499,804 for 1 year

Abstract:

The National Institute of Justice (NIJ) is soliciting research and development projects to enhance instrumental methods of analysis employed within forensic science disciplines. Specifically, NIJ is seeking studies that develop novel analytical techniques to analyze, interpret evidence, and improve the reliability, reproducibility, selectivity, and/or sensitivity of current methods used in crime laboratories for forensic analysis. Currently, RTI International's* (RTI's) Center for Forensic Sciences (CFS) has been constructing a Web-searchable, centrally curated database of spectral data on compounds of forensic interest under NIJ grant number 2008-DNBX- K180. This database includes nominal mass electron impact spectra, accurate mass DARTTOF (direct analysis in real time [DART] coupled with a time-of-flight [TOF] mass spectrometer) spectra, and Fourier transform-infrared (FTIR) spectra. Additionally, RTI has worked with the DART-TOF system under NIJ grant number 2006-DN-BX-K014 and has collected reference spectra for more than 100 drugs of interest to the toxicology community. It has become apparent that a widely available, searchable database of multiple types of spectral data would be of great utility. A curated and peer-reviewed database with processes in place to help verify the validity of the information in the database is critical to meet the needs of forensic applications. The objectives of this proposal are to (1) extend the database platform established (as www.forensicDB.org) for both the continued maintenance of this structure, as well as to expand its capacity; (2) expand the database to include nuclear magnetic resonance (NMR) data so as to provide more complete data and flexibility to the forensic community using technologies widely used in other chemistry disciplines; and (3) improve the management structure with additional associate curators and additional automation of record handling.

RTI will collaborate with a public forensic laboratory, the Virginia Department of Forensic Sciences; a commercial forensic laboratory, NMS Laboratories; two universities, the University of Colorado and the Albany Medical Center Hospital and College; a professional organization working to create a database of scheduled compounds, the Southern Association of Forensic Scientists (SAFS); and a software developer, ACDLabs, to further develop the database. All these institutions have acknowledged the need for a unified database approach and have agreed to collaborate in its development. In this proposal, RTI is also bringing chemists from the larger chemistry community, specifically medicinal chemistry and

cheminformatics, to help add additional spectral characterization records to the database and add additional expertise in the design and management of cheminformatic databases. The first phase of the proposed work will expand query capacity and bandwidth of the database infrastructure and secure licensing of all components to extend the life of the database. The second phase will incorporate additional associate curators, provide them with software tools, and implement additional spectral information components, specifically NMR spectra and routine pKa calculation for all records for which a chemical structure has been determined. The third phase will work with associate curators and collaborators to further expand additional automation for record handling and management. RTI has established relationships with many forensic laboratories and organizations across the country, which will facilitate wide dissemination of the study results to the forensic community.

NIJ Point-of-Contact

Program Manager: Frances Scott

2010-DN-BX-K244

Stoney Forensic, Inc

“Use of Scanning Electron Microscopy / Energy Dispersive Spectroscopy (SEM/EDS) Methods for the Analysis of Small Particles Adhering to Carpet Fiber Surfaces as a Means to Test Associations of Trace Evidence in a Way that is Independent of Manufactured Characteristics”

Principal Investigator:

Dr. David Stoney
dastoney@core.com

Funding Amount:

$308,239 for 1 year

Abstract:

We will develop and test an innovative instrumental trace evidence analysis approach based on the recovery and quantitative SEM/EDS analysis of fine particles that are found adhering to the surfaces of conventional trace evidence materials. Analysis of these "piggy back" particles can remove a fundamental limitation to the probative value of trace evidence, and provide an independent quantitative means to test hypotheses of common origin. The potential significance of this new instrumental approach is extremely high – ultimately it could provide the means to fundamentally change the probative value of trace evidence from one of class association to one of highly individual, testable associations (akin to those arising from multiple-transfers of uncorrelated traces, or the co-occurrence of independent, highly variable events).

To develop and test this new approach, we have chosen carpet fibers as the target conventional trace evidence material. Carpets are common in indoor domestic and many commercial environments, and they are ubiquitous in automobiles. Carpet fibers are easily shed, easily transferred, easily recognized on careful examination, and easily recovered. They are also the most likely candidates, among conventional trace evidence types, to be suitable for this approach: they are subject to long-term exposures, they have a tremendously large exposed surface area, and they are designed to trap small particles. Our preliminary data show fine particles to be present on carpet fibers, easily removable by extraction, and suitable for quantitative analysis by computer-controlled SEM/EDS methods.

The goals of the present research are (1) to develop methodologies to quantitatively remove these particles and prepare them for SEM/EDS analysis, and (2) to exploit existing computer controlled SEM/EDS methods to test whether the resulting fine particle profiles are useful to quantitatively associate shed fibers with a source carpet. The within-source variability – how much the fine particle profile varies among fibers from the same carpet – is unknown and needs to be measured.

Specific program objectives are to:

(1) Develop methods, compatible with existing fiber analysis protocols, and using currently available crime laboratory resources, to quantitatively remove and analyze the fine particles adhering to carpet fibers.
(2) Use these methods to determine fine particle profiles within source carpets.
(3) Analyze fine particles adhering to fibers that have been shed from the source carpets, and determine if the profiles occurring on these fibers are consistent with an unbiased statistical sampling from the source carpet population.
(4) Conduct a broader qualitative survey of carpet particle profiles to explore between item variation.

Immediate expected outcomes are fundamental understanding of the of the next (finer) dimension of particles and their potential use in trace evidence applications, providing the impetus and direction for follow-on research, as well as guiding the allocation of laboratory resources, and policies for collection of crime scene evidence types and control samples.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2010-DN-BX-K246

Combustion Science & Engineering, Inc

"Forensic Investigation Techniques for Inspecting Electrical Conductors Involved in Fire"

Principal Investigator:

Dr. Richard Roby
rroby@csefire.com

Funding Amount:

$205,087 for 1 year

Abstract:

Fire investigators, often, rely on the appearance of electrical wires and the presence of electrical activity (e.g. arc-beads) on wires to assess the potential involvement of the wires or attached appliances in the initiation of the fire. Many times, a fire investigator will conclude that a device was electrically energized at the time of a fire, and therefore, could have potentially caused the fire, based on the presence of an arc bead on a wire. Hence, a clear understanding of the causes of various effects, such as arc beads, on electrical wires is invaluable to the community. Unfortunately, there are many limitations in the current state-of-the-art for electrical wire analysis. Although many researchers have attempted to define the conditions under which particular characteristics occur on electrical wires, many, if not all, of these studies did not test a control. For example, if it is believed that arc beads are only formed in energized wires, then a control study must be performed to ensure that the same characteristic "bead" cannot be formed on non-energized wires.

The main objective of this research is to determine, experimentally, if distinguishing characteristics exist between energized and non-energized wires exposed to various types of thermal exposures; direct flame impingement, radiative heating only, and radiative/convective heating. Additionally, energized wires will be tested under "load" and "no load" conditions. Under load conditions, the energized wire will have current flow and under "no load" conditions, the energized wire will be plugged into a power source but no current will be flowing through the wire (e.g. electrical potential only). After thermal testing, the wires will be analyzed with a high resolution stereomicroscope, as well as, a Scanning Electron Microscope (SEM) and Electron Dispersive Spectrometry (EDS) to define visual and elemental characteristics and Fire investigators, often, rely on the appearance of electrical wires and the presence of electrical activity (e.g. arc-beads) on wires to assess the potential involvement of the wires or attached appliances in the initiation of the fire. Many times, a fire investigator will conclude that a device was electrically energized at the time of a fire, and therefore, could have potentially caused the fire, based on the presence of an arc bead on a wire. Hence, a clear understanding of the causes of various effects, such as arc beads, on electrical wires is invaluable to the community. Unfortunately, there are many limitations in the current state-of-the-art for electrical wire analysis. Although many researchers have attempted to define the conditions under which particular characteristics occur on

electrical wires, many, if not all, of these studies did not test a control. For example, if it is believed that arc beads are only formed in energized wires, then a control study must be performed to ensure that the same characteristic “bead” cannot be formed on non-energized wires.

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The Scientific Method, the basic tenet of fire investigation, requires that the investigator identify the problem, define the problem, collect and analyze the data, develop and test hypotheses, and select a final hypothesis A fire investigator’s ability to rule out one or more cause and origin hypotheses, as set forth in the Scientific Method, is dependent on the evidence available to support one particular hypothesis and the factual nature of that evidence. Because the collected data may lead to the development of multiple hypotheses, these hypotheses must be tested against all available data to ensure an objective analysis and to determine, through deductive reasoning, which hypothesis is most probable. This research will have a significant impact on the fire investigation community because it will provide investigators with a validated methodology for analyzing electrical conductors and associate devices. The outcomes of this proposed research would provide the fire investigator with the additional scientific evidence needed to make a conclusive and accurate determination of the origin and cause of the fire.

NIJ Point-of-Contact

Program Manager: Brigid O’Brien

2010-DN-BX-K179

Florida International University

"LA-ICP-MS and LIBS Analysis of Paper, Inks, Soils, Cotton and Glass"

Principal Investigator:

Dr. Jose Almirall
almirall@fiu.edu

Funding Amount:

$283,090 for 1 year

Abstract:

The development of methods of analysis for the elemental characterization of writing inks, paper, cotton and soils is proposed with the use of Laser Induced Breakdown Spectroscopy (LIBS). The proposed project extends the successful application of LIBS for the analysis of glass by our group (and by other researchers) to the analysis of other matrices of interest to forensic scientists. Unlike previous studies, this effort will use commercial instrumentation, rather than in-house built instruments, in order to facilitate the transfer of the research to the operational laboratory quickly. The main advantage of LIBS as an analytical tool is the capability to detect practically the entire periodic table of the elements very quickly and without the need of a sophisticated operator. Detection limits on the order of 10-50 ppm are routinely attainable, for most elements, with the commercial instruments currently available. The three commercial systems currently available (Foster and Freeman, Photon Machines and Applied Spectra) will all be evaluated for the figures of merit required for the matrices selected for the project (all these instruments are already maintained in the Almirall laboratory). The operating parameters for the commercial instruments will be optimized with an aim towards creating standard methods of analysis for the examination of these types of evidence. The commercial LIBS instrumental results will also be compared to our already optimized in-house LIBS system and also to the alternative forensic tools of LA-ICP-MS and to μXRF, both of which offer good analytical performance but suffer from either very high cost and significant complexity (in the case of LA-ICP-MS) or analytical limitations in the form of sample requirement and relatively high detection limits (in the case of μXRF). Some of the recognized advantages of LA-ICP-MS include direct characterization of solids, elimination for the need for chemical procedures for dissolution, minimum consumption of the sample (< microgram), high sensitivity and high selectivity. Although less mature than LA-ICP-MS, LIBS also shares the benefits associated with laser ablation methods with the added advantage of improved speed, versatility, ease of operation, affordability and portability. The costs of any of the commercial instruments are less than ~ $ 100. k. It is expected that at the conclusion of this effort, standard methods of analysis will be developed on commercial instruments for rapid transfer of these methods to the average trace evidence analysis section for routine use in casework.

At the conclusion of this project, the PI will conduct a workshop, free of charge, on the campus of FIU for practicing forensic scientists describing the theory and practice of LIBS for the analysis of a variety of matrices, including ink, paper, soils and cotton.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2010-DN-BX-K201

Las Vegas Metropolitan Police Department

"Research and Development on Instrumental Analysis for Forensic Science Applications"

Principal Investigator:

Ms. Linda Krueger
l1471k@lvmpd.com

Funding Amount:

$118,322 for 1 year

Abstract:

The Las Vegas Metropolitan Police Department (LVMPD) Forensic Laboratory is proposing research that involves the enhancement of Raman field technology to provide a presumptive onsite analysis of controlled substances. This field technology, in the form of a handheld instrument, is small and rugged, and involves less labor intensive methods than the chemical field tests. The research will focus on enhancing a portable device to improve its reliability, reproducibility, selectivity, and sensitivity.

Current presumptive onsite analysis of controlled substances consists of adding suspected controlled substance to chemicals in a premade commercially prepared kit and observing a color change. LVMPD officers use this method to presumptively identify frequently encountered drugs, such as cocaine, methamphetamine, and marijuana. The police officer then presents these results in lieu of laboratory analysis for preliminary hearing purposes. Other US agencies, like the Phoenix Police Department, also utilize this field testing and preliminary hearing process [30].

Recently, the LVMPD program was compromised by false positive results for methamphetamine. The District Attorney's Office determined that this may lead to individuals being falsely accused, and as a result, the field tests could not be used until the prevalence of false positives was established. This resulted in an increased backlog and delays in court.

Recognizing the need to find a more reliable and specific method for presumptive field testing, the LVMPD laboratory began investigating the use of Raman infrared spectroscopy. Unlike the current field testing method, Raman spectroscopy is highly specific and has the ability to identify a suspected drug based on the substance's molecular structure [3]. Moreover, Raman instrumentation can detect substances through the packaging commonly used with illicit substances [4] providing important safety benefits for the tester. Capabilities of existing portable Raman technology have been reported to detect controlled substances [27,28,29], however the technology has not been widely implemented in a field testing program. Preliminary testing by the LVMPD Forensic Laboratory with a portable Raman device failed to successfully differentiate false positives from methamphetamine. After reporting our findings to the manufacturer, they were able to implement improvements to the hardware and software, thereby significantly improving the device's accuracy and reproducibility. The LVMPD would like to

expand on this in order to test the specificity, sensitivity, reliability, and reproducibility of the technology in identifying methamphetamine as well as cocaine and marijuana. The ultimate goal will be to develop a new field testing program.

The laboratory will test the device's reproducibility and reliability by examining hundreds of casework samples of suspected methamphetamine, cocaine, and marijuana, testing numerous standards, and examining its calibration stability. Selectivity will be determined through testing substances that are similar in appearance and chemical structure to methamphetamine, cocaine, and marijuana. Selectivity and sensitivity will be addressed in a parallel study of portable Raman technology with a laboratory-grade Raman microscope. If the research is successful, a new method of field testing, using improved technology, will enhance the ability of the forensic science community to identify, analyze and interpret controlled substance evidence. This will enhance the administration of justice and public safety by providing law enforcement with a robust tool that gives immediate and defendable results for cocaine, methamphetamine, and marijuana.

NIJ Point-of-Contact

Program Manager: Frances Scott

2010-DN-BX-K176

Marquette University-Office of Research & Sponsored Programs

"Replication of Known Dental Characteristics in Porcine Skin: Emerging Technologies for the Imaging Specialist"

Principal Investigator:

Dr. L. Thomas Johnson
forensicdoc@wi.rr.com

Funding Amount:

$715,347 for 3 years

Abstract:

Controversy about the validity of forensic bitemark evidence continues to be a topic widely discussed in both the public media and scientific community. The National Academy of Science Forensic report in 2009 (NAS), a Congressionally mandated report, has challenged the comparative science disciplines to develop comprehensive reforms and research to provide scientific methodology for analyzing reports, protocols and standards in the reporting of evidence. [1] In addition, the 2009 report to Congress directed the various comparative forensic sciences to establish a scientific basis and reliability for the many forensic methods. Important to bitemark evidence is the extent to which there is science in the evaluation of evidence. Stated in the NAS report, the law relies on two questions regarding evidence admissibility: the extent to which a particular discipline is based on scientific method and the ability to correctly analyze the evidence. The second of these, correctly analyzing evidence, relies on human interpretation which could be flawed by error, bias, faulty procedure and robust performance standards. The goal of law enforcement should be directed toward correctly identifying those who commit crimes and to prevent erroneous conviction of the innocent. [1]

Having these concepts in mind, the investigative team has initially developed a means of establishing a data set quantifying seven characteristics of the human dentition. The methodology has been established and tested repeatedly for interoperator and intra-operator error rates with the result being that the methodology and protocol have a confidence level of 95% and a confidence interval of ±1.55 using a sample size that mirrors the male population between the ages of 18-44 years in the State of Wisconsin.

Using in-vivo porcine skin to replicate patterned injuries in human skin has had widespread acceptance in the medical and dental literature. Numerous studies and methods have been developed to account for stresses necessary to produce bitemarks that limit the variables in location, existing dentition, pressures, relative movement of the victim, the device creating the bite and the recovery of patterned evidence along with the method of interpretation. Earlier studies did not show the ability to match a given patterned injury with a known data set. This project will determine the amount of agreement between a patterned injury in a porcine model to a known data set of seven dental characteristics by

using standardization and methods previously reported and accepted as valid. A completely randomized block design will be employed for statistical analysis. In addition to reporting whether a match was made between the bitemark and the known data set, a method of patterned analysis will be evaluated to determine the ability of the forensic investigator to link pattern recognition analysis to the bitemarks in the same manner that has been used for fingerprint and document examination. As a result, an expanded set of data could be gathered and stored for rapid pattern recognition utilized as a universal means of bitemark analysis. Standardization of techniques will enhance the confidence level of law enforcement in the utilization of the information that can be provided in any particular case involving bitemark evidence.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2010-DN-BX-K236

Microtrace LLC

"Fundamentals of Forensic Pigment Identification by Raman Micro-Spectroscopy: A Practical Identification Guide and Spectral Library for Forensic Science Laboratories"

Principal Investigator:

Dr. Christopher Palenik
cpalenik@microtracescientific.com

Funding Amount:

$237,977 for 1 year

Abstract:

Pigments are encountered in a many kinds of trace evidence, including automotive, architectural, tool and appliance paints, inks, fibers, plastics and other polymers. They are responsible for the color, which is one of the most important physical characteristics of these materials. Traditionally, pigments have been studied by polarized light microscopy, microchemistry, infrared spectroscopy, py-GC/MS, SEM/EDS and X-ray diffraction. Limitations inherent to each of these techniques have constrained the practical use of pigment identification in the analysis and comparison of trace evidence since none of these methods, when used alone, provide unequivocal identification of the pigment or pigments present. Raman spectroscopy, which is becoming more widely available in forensic science laboratories, is the first analytical technique to provide the spatial resolution, sensitivity and specificity necessary to identify pigments *in situ* while still occluded in the paint film or other binder.

Over the past four years, through internally funded research, we have demonstrated the promise of Raman spectroscopy as a technique for identifying both pigments in their free form and *in situ* in architectural and automotive paints and in inks. During this period, a preliminary Raman spectral library of approximately 200 different pigments was established. This includes the most common automotive paint, architectural paint, and printing pigments. Practical applications of Raman spectroscopy to pigment identification in forensic casework has demonstrated the value of this method and the need for further refinement and development of this aspect of trace evidence analysis.

With the development of this Raman database and its use in practical casework, several higher level questions have arisen that must be answered prior to the more widespread use and dissemination of this "technology" throughout trace evidence laboratories. These questions revolve around the following three unexplored questions:

- Are the Raman spectra from a given pigment reproducible?

- Given the difficulty of obtaining pigment reference samples, how reliable are obtainable reference samples and do they vary from manufacturer to manufacturer?
- Finally, and most significantly, to what extent can a given pigment be specifically identified by Raman spectroscopy?

Preliminary research conducted and presented by Microtrace suggests that these questions can be answered; however, systematic research is needed to rigorously quantify, verify, and distribute this information. In answering these questions, we anticipate the development of a systematic pigment identification manual including narrative and illustrated discussions of sample preparation, analysis, and interpretation of pigment evidence. This information would be directly applicable to casework in any forensic laboratory with a macro-, micro-, or even handheld Raman spectrometer. This research, while directed specifically at paint evidence, would be of utility and interest to other areas of forensic science such as fibers examination (some fibers, for example those used in many vehicles, are pigmented rather than dyed), ink characterization, and analysis of many other types of colored polymers and materials.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2010-DN-BX-K243

Texas A&M Research Foundation

"Development and Validation of Standard Operating Procedures for Measuring Microbial Populations for Estimating a Postmortem Interval"

Principal Investigator:

Dr. Jeffrey Tomberlin
JKTomberlin@ag.tamu.edu

Funding Amount:

$476,348 for 3 years

Abstract:

Predicting the postmortem interval of a decedent is a major task of law enforcement. Most methods implemented by death investigators rely on qualitative information (i.e. rigor mortis, livor mortis). Microbes represent 99% of somatic cells in and on a human body. No data are available on the use of these organisms to predict the time since death of a decedent, though it is known that certain chemicals, many of which are likely a result of microbial communities, are released by decomposing remains in a reliable pattern. Moreover, the effects of microbes on insect colonization of remains, sometimes the best predictor of a postmortem interval, are not understood. Because of a lack of understanding of microbial succession on decomposing human remains, no standard operating procedures (SOP) for sampling and using this information has been developed and validated. We propose to develop a SOP for sampling and pyrosequencing microbial communities on human remains to predict the actual time since death. We will conduct a series of laboratory and field studies to achieve this end. The field studies will implement the SOP for sampling microbes on decomposing human remains at the Sam Houston University Anthropology Research Center. Once the lab and field components have been completed, the SOP will be validated through the Crime Scene Investigators Course which is part of the Forensic Sciences Academy with Texas Engineering Extension Service. This last objective will lead to validation of the SOP with the implementation of our methods by actual crime scene investigators simultaneously. This will also result in the development of an SOP that meets standards outlined by the National Research Council report on forensic sciences.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2010-DN-BX-K245

University of South Carolina Research Foundation

"Validation of Forensic Characterization and Chemical Identification of Dyes Extracted from Millimeter-length Fibers"

Principal Investigator:

Dr. Stephen Morgan
morgan@chem.sc.edu

Funding Amount:

$451,336 for 2 years

Abstract:

The objective of this proposal is to validate analytical methods for the forensic chemical characterization of dyes extracted from trace evidence fibers, thereby enhancing discrimination for comparison of known and questioned casework fibers. Previous work in our laboratory with microextraction techniques coupled with capillary electrophoresis (CE) and mass spectrometry (MS) has demonstrated highly discriminating and sensitive forensic analysis of fiber dyes. Extraction protocols for (basic) dyes on acrylic, (direct, reactive, and vat) dyes on cotton, (acid) dyes on nylon, and disperse dyes on polyester have been developed that are compatible with CE. We propose to extend this work by also developing liquid chromatography (LC) methods with fluorescence or mass spectrometric (MS) detection for dye analysis. The development and application of CE/MS and LC/MS methods will proceed concurrently with method validation studies using international guidelines for performance characteristics such as selectivity, linearity, working range, limits of detection and quantitation, accuracy, and precision. Collaboration with the State Law Enforcement Division (SLED) Forensic Services Laboratory (Columbia, SC) will insure the forensic casework relevance of samples analyzed and the applicability of the methods developed to forensic practice. With input from SLED, our collection of over 700 dyed and undyed fibers and samples of textile dyes will be expanded to include additional forensically relevant fibers. Method development and validation will specifically target the analysis of dye extracts from single fibers ranging from just a few millimeters down to the millimeter size. One planned study involves an evaluation of intra- and inter-batch dyeing variability by sampling across and longitudinally down different dye batch from a textile manufacturing process. A second interlaboratory study will evaluate error rates in

comparisons of “questioned and known” pairs of samples. The collaboration with SLED will serve to disseminate methodology that will enhance their analytical capabilities for trace fiber analysis. In addition to producing required reports, presentations, and publications, a prototype web-based database for sharing of project information will be established.

NIJ Point-of-Contact

Program Manager: Brigid O’Brien

2010-DN-BX-K247

West Virginia University Research Corporation

"On-Site Confirmatory Test for Tissue Type and Specimen Age"

Principal Investigator:

Dr. Clifton Bishop
cbishop@mail.wvu.edu

Funding Amount:

$146,055 for 1.5 years

Abstract:

Collection and processing of potential evidentiary samples at a crime scene is critical to the successful resolution of an investigation and various presumptive and confirmatory tests are available to assist the crime scene investigator in selecting which specimens to process. Most presumptive tests can be performed at the crime scene itself but many of the confirmatory tests must be performed at the crime laboratory. The success, sensitivity, and popularity of DNA profiling has frequently resulted in the collection of a large number of samples at many crime scenes, resulting in increased costs to investigate a crime and often a considerable backlog in the processing of such samples. We propose to develop a universal confirmatory assay that can be used while still at the scene of a crime. This single, multiplexed assay will positively identify the nature of the specimen (blood, semen, or saliva or a mixture of the three) and provide a rough estimate of the ex vivo age of the specimen. The assay exploits the presence of alternatively spliced mRNA variants found in different human tissues. The splice variants are recognized and reported by a multiplex reaction containing fluorescent probes, known as molecular beacons, which span the nucleotide sequences at the site of the splice variation. The emission wavelength of the attached probes is read by a portable fluorospectrometer after a simple RNA isolation procedure. The wavelengths measured are indicative of bodily fluid content within the stain. To measure time since deposition, the ratio of degradation of two different species of RNA, mRNA and rRNA, are compared in a technique much like that of carbon-14 dating. The combination of information provided by the single, multiplexed assay (stain type identification and age) can lead to exclusion or inclusion of a particular piece of potential evidence from a crime scene. Exclusion of non-evidentiary specimens from collection, processing, and DNA profiling can represent a significant savings in terms of both time and money. We estimate the cost of the equipment required for this

portable forensic laboratory to be between $13,000 to $15,000, with each assay costing approximately five dollars. If the reviewers should deem the equipment required to execute the technique not sufficiently portable to take to a crime scene, we believe that the technique would be a cost-effective replacement of current, more expensive, and laborious technologies.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

2008-IJ-R-134

Oak Ridge National Laboratory

"Universal IR Fluorescent Latent-Print Detection Method"

Principal Investigator:

Dr. Linda Lewis
lewisla@ornl.gov

Funding Amount:

$440,013 for 1.5 years

Abstract:

In a 2008 – 2009 project sponsored by Technical Support Working Group (TSWG), researchers from the Oak Ridge National Laboratory (ORNL) teamed with the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) Forensics and Explosive Ordinance Disposal (EOD) units in Atlanta, Georgia to conduct experiments aimed to identify fingerprint constituents that survive on post blast improvised explosive device (IED) fragments and components. The goal of this effort was to develop new, robust latent fingerprint detection techniques targeting fingerprint components that survive thermal and photo-degradation events, such as that experienced in an IED detonation. In order to characterize post blast surviving constituents, several series of detonations were performed, first to quantitatively study the amounts of eccrine and sebaceous constituents that remain after detonations of low and high explosives contained within metal and plastic devices. Surviving constituents of artificial fingerprint solutions and subsequently real fingerprints were characterized (amino and fatty acids persist), and four new latent fingerprint detection methods were developed targeting the surviving components. A down-select of the methods was conducted to identify the most robust new methods by exposing latent prints on stainless-steel planchets to low- and high-explosive detonations in galvanized steel and PVC containers. One of the four methods, based upon IR- 797, an infrared-active dye that complexes with surviving amino and fatty acids, was identified as the most promising technique. The IR-797 dye was found to not interfere with subsequent superglue fuming and also developed prints on previously superglue-fumed samples. Post blast high-explosive samples that yielded non-identifiable prints due to the lack of any ridge detail with superglue and Rhodamine 6G treatment successfully produced fingerprint ridge detail by a subsequent IR 797 dye treatment.

During the TWSG effort, the IR-797 dye method was found to complex with amino and fatty acids to yield IR fluorescent latent prints. The method was found to be a universal print development method capable of developing prints on both porous and non-porous surfaces. However, many optimization parameters are needed in order to transition this new technology into a robust and fieldable method. In this National Institute of Justice (NIJ) effort, ORNL researchers and ATF latent print examiners and EOD officers propose to address the stated IR- 797 method deficiencies, the optimization of the (1) IR-797 print development solution, (2) latent print screening, and (3) print imaging systems, as well as the

development of a fieldable, hand-held fine mist sprayer. Once these tasks are completed, an overall optimization effort is planned, targeting a protocol that maintains a low background/high print contrast for each surface studied. The following materials/surfaces will be included in the proposed system study: fired ammunition casings, weapons, low and high explosive post blast metals and PVC pipe fragments, with associated components, paper, metal, plastic, tape, glass, and wood/liniments. For each surface, optimum print development and detection parameters will be identified.

The proposed ORNL/ ATF effort will facilitate the development of a robust and practical latent fingerprint detection method that may be expedited directly into the practitioner's hands. ORNL has a basic understanding of fingerprint chemistry and fingerprint chemistry research needs. ATF has the expertise in latent print collection, quality, and identification issues, as well as the required experience to generate post blast IED samples for print detection optimization. Thus, with this team, the likelihood of success and delivery of a universal print detection method targeting all print types on a broad range of surfaces is very high.

NIJ Point-of-Contact

Program Manager: Brigid O'Brien

#4. Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines

Posting Date: March 2, 2010

Closing Date: April 16, 2010

Awards Made: 21

With this solicitation, NIJ sought qualified applicants to conduct research to improve the understanding of the accuracy, reliability, and measurement validity in the forensic science disciplines. Although not discipline-specific, this solicitation's intended focus was primarily on the forensic disciplines that are considered to be semi- and highly-qualitative in nature.

The individual discipline categories that were targeted by this solicitation include:

1. Firearms and Toolmark Identification
2. Questioned Documents
3. Trace Evidence
4. Fire Debris Analysis and Arson Scene Investigations
5. Latent Print Examination
6. Blood Pattern Analysis
7. Digital Evidence
8. Forensic Pathology/Death Investigation

The most competitive proposals addressed a combination of the following specific research topics:

- Strengths and limitations of a specific forensic method or methods
- Sources of bias and variation
- Quantification of uncertainties created by these sources
- Measures of performance
- Procedural steps in the process of analyzing forensic evidence
- Methods to continuously monitor and improve the steps in the forensic evidence analysis process

FY 2010 Fundamental Forensic Science Research Awards

Grant Number	Grantee	Title	Page #
2010-DN-BX-K270	Complete Consultants Worldwide, LLC	Quantified Assessment of Contextual Information in Latent Friction Ridge Impression Analysis Related To Accuracy and Reliability of Subsequent Examiner Suitability Determinations	Pg. 140
2010-DN-BX-K235	County of Harris	Independent Validation Test of Microscopic Analysis of Saw Marks in Bone	Pg. 142
2010-DN-BX-K222	Harris County	Gunshot Residue in a Non-Firearm-Related Detainee Population	Pg. 144
2010-DN-BX-K216	Iowa Department of Public Health	The effects of acquisition of postmortem blood specimens on drug levels and the effects of transport conditions on degradation of drugs	Pg. 145
2010-DN-BX-K271	Kentucky State University	Validity, Reliability, Accuracy, and Bias in Forensic Signature Identification	Pg. 147
2010-DN-BX-K219	University of California - Davis	Determination of Unique Fracture Patterns in Glass and Glassy Polymers	Pg. 149
2010-DN-BX-K267	The Pennsylvania State University	Improving the Understanding and the Reliability of the Concept of "Sufficiency" in Friction Ridge Examination	Pg. 150
2010-DN-BX-K221	Southwest Research Institute	Reducing Uncertainty of Quantifying the Burning Rate of Upholstered Furniture	Pg. 152
2010-DN-BX-K217	Oklahoma State University	Improving Investigative Lead Information and Evidential Significance Assessment for Automotive Paint and the PDQ Database	Pg. 154
2010-DN-BX-K273	University of Central Florida	Frequency Occurrence of Handwriting and Hand-Printing Characteristics	Pg. 156

2010-DN-BX-K270

Complete Consultants Worldwide, LLC

"Quantified Assessment of Contextual Information in Latent Friction Ridge Impression Analysis Related to Accuracy and Reliability of Subsequent Examiner Suitability Determinations"

Principal Investigator:

Mr. Kasey Wertheim
kaseywertheim@aol.com

Funding Amount:

$452,050 for 1 year

Abstract:

We will study a little recognized aspect of latent print analysis, the determination of whether or not a latent print offers suitable data for identification of the source. This analytic task exists both within and without the examination proper. A natural and important determination that is made during Analysis1 is whether the impression presents sufficient detail to accomplish an individualization2, should a clear source impression (the "record print") be available.

This study seeks to discover whether bias exists and if so, the extent to which it exists as examiners conduct analysis on casework-quality latent prints. We explore three important types of potential examiner bias: 1) case value context - whether or not the perceived importance of the identification (murder) or unimportance of the identification (theft) affects suitability determination of a latent friction ridge impression, 2) knowledge of a previous examiner suitability determination - whether or not the knowledge that a latent print was previously deemed to be suitable or previously deemed to be unsuitable for identification affects subsequent examiner suitability determinations, and 3) paired image bias - whether or not the absence, or the presence of a matching or a non-matching candidate image affects subsequent examiner suitability determinations.

We will create and make available a large Latent Friction Ridge Suitability Dataset of 6400 latent print impressions, and test each bias by conducting studies to isolate each potential factor. We will conduct these tests using images that have been graded by four well-respected IAI Certified Latent Print Examiners to be suitable, not suitable, or questionable (based upon mixed results). We will administer examination jobs of varying difficulty to both IAI Certified and noncertified examiners of varying qualification levels in order to quantitatively determine if there is a trend to any biasing effects we find.

During the study, we will present the same images to different examiners to obtain measures of consistency, and determine if any effect we find is related to other biasing factors or examiner qualifications. Furthermore, and in fact more importantly, if examiners are not consistent, we will collect, analyze and publish data that quantifies the variances and provides ideas about why they are not consistent. This will be accomplished using a new and extensive latent print annotation capability for

complex examinations so that examiners can mark what they are looking at during the examination. This software capability will allow us to tease apart the different contributing factors to any inconsistency we find:

1) DETAILS: When different examiners use the same details, will they consistently arrive at the same suitability determinations?
2) WEIGHT OF THE DETAILS: Using the same details, will different examiners consistently arrive at the same suitability determinations if the weight/importance they assign to these details is different?
3) SUITABILITY THRESHOLD/CRITERION: Using the same details and weights, will different examiners consistently arrive at the same suitability determinations if their suitability thresholds are different?

Each of these three factors can cause inconsistencies, and it is important for examiners to see annotations and study separate examples where each one of these factors resulted in examiner inconsistency in their findings of suitability. Finally, we will make widely available to the community this very interesting dataset and the results of this study in various formats and locations at the conclusion of the project.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K235

County of Harris, Texas

"Independent Validation Test of Microscopic Analysis of Saw Marks in Bone"

Principal Investigator:

Dr. Jennifer Love
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Funding Amount:

$26,409 for 2 years

Abstract:

Microscopic analysis of saw marks in bone is a well published, generally accepted, and commonly used method. The strength of the method is that it is based on easily recognized qualitative and quantitative characteristics of a saw mark using standard laboratory equipment, a stereomicroscope. Despite the method's attractiveness, it has not been independently validated, nor has the potential error rate been defined. Federal guidelines regarding admissibility of forensic testimony have become more rigorous in recent years, requiring a defined potential error rate. As a result, microscopic analysis of saw marks fails to meet the requirement set forth by the Federal Rules of Evidence.

The following research proposal defines a two part study. The first component of the study is an independent validation test of microscopic analysis of saw marks. The method as described by Symes (3) is replicated without deviation and an ample sample size is generated for statistically robust analysis. Three morphologically different saws are used to make 30 partial and 30 complete saw marks in human long bone segments. The saw marks are examined by three doctoral level anthropologists using a standard laboratory stereomicroscope. The qualitative and quantitative characteristics are documented for each saw mark. A statistician is contracted to assess the correlation between each feature and the saw type. Using a linear regression model, the statistician defines the probability of identifying the correct saw blade type based on the variables. The goal of the research is to identify the potential error rate associated with the method and to develop and disseminate best practices.

During the second component of the study, two novel features of the saw mark are evaluated: 1) depth of the striations, and 2) depth of the tooth dips. These features are hypothesized to reflect the size of the saw teeth and to reduce the potential error rate when considered in conjunction with the previously defined saw mark characteristics. The saw marks created during the first component of the study are reexamined for the striation and tooth dip depths using a Keyence digital microscope. The results of the second component of the study are analyzed by the statistician using the same statistical models as used in the first component.

The result of the study is a quantified measure of the uncertainty in the conclusions drawn from saw mark examination, defining the limits of reliability and the accuracy that the method can achieve. The

end product of the study is defined best practices that identify minimal specimen requirements for successful application of the method and responsible statements of conclusion that are within the reliability limits of the method. The proposed program culminates with dissemination of the results to forensic anthropologists through the American Academy of Forensic Sciences and the Journal of Forensic Sciences.

The Harris County Forensic Anthropology Division is capable of performing the analysis. The Division includes three doctoral-level anthropologists, one certified by the American Board of Forensic Anthropology, with combined 18-years of experience working in the medical examiner's office setting. The Division is currently finalizing the results of a similar study on knife mark impression evidence in costal cartilage funded through the Social Science Research in Forensic Science (No. 2008-NIJ-1735) that has successfully defined best practices and the potential error rate of the method.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K222

Harris County

"Gunshot Residue in a Non-Firearm Related Detainee Population"

Principal Investigator:

Dr. William Davis
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Funding Amount:

$88,837 for 1.5 years

Abstract:

The forensic discipline of gunshot residue (GSR) analysis is one which could be strengthened by the use of statistical evaluations of the most representative population of interest. Persons placed under arrest or detained by law enforcement are members of that population. This program is designed to sample and report the average amount of GSR found on a member of said population. The Poisson distribution function would then allow an inference as to the probability of finding a pre-determined number of GSR particles on any given person suspected of being in the vicinity of a discharged weapon.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K216

Iowa Department of Public Health

"The effects of acquisition of postmortem blood specimens on drug levels and the effects of transport conditions on degradation of drugs"

Principal Investigator:

Dr. Dennis Klein
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Funding Amount:

$167,697 for 1 year

Abstract:

Postmortem toxicology tests are necessary components of many forensic autopsies to elucidate the cause and manner of death, provide information for criminal and civil court proceedings and epidemiologic drug use trends. While most forensic pathologists understand the influence of postmortem drug redistribution in drug level interpretations, careful acquisition and preservation f specimens may not be a priority. Many forensic pathologists rely on "blind sticks," obtaining femoral venous blood by externally aspirating from the inguinal region, often while vigorously massaging the leg producing a mixture of femoral, peripheral, and possibly central venous blood. Another potential problem in postmortem toxicology interpretation involves possible degradation of drugs during the storage and transportation of specimens to a toxicology laboratory. Drugs like cocaine and nitrobenzodiazepines are unstable and tend to degrade in adverse conditions. Medical examiner or coroner offices may not have the luxury of an on-site toxicology lab and may have to ship their specimens to a toxicology that may be in another state. The specimens are usually stored in a refrigerator then shipped under ambient conditions. It is currently unknown how this method of shipping affects the stability of drugs in blood specimens.

Much of the forensic and toxicology literature has focused on improvement of analytical techniques to detect certain drugs or focused on postmortem redistribution of a single specific drug. Studies concentrating on pre-analytical conditions, which are conditions prior to processing in the lab, are not as common. Over 1 year, we propose to use a state medical examiner's office that provides guidance to county medical examiners and performs forensic autopsies for a population of roughly 2,284,993 people in conjunction with an accredited toxicology laboratory to evaluate 2 pre-analytical conditions that may impact interpretation of postmortem drug levels. We will prospectively analyze the effect, if any, that routine external acquisition of femoral blood specimens may differ from careful internal, site-specific acquisition of blood. We will also prospectively analyze the effect, if any, that careful preservation of specimens by freezing immediately after acquisition and shipping on dry ice to maintain a frozen state until processing may differ from refrigeration of specimens then shipping in ambient conditions.

We will evaluate no more than 250 cases where there is a high possibility of presence of various drugs in the blood based on scene evaluation and circumstances. All specimens will be tested in the same manner according to the toxicology laboratory protocols. The data will then be evaluated by a board-certified forensic toxicologist and forensic pathologist.

If test results indicate significant changes in drug levels, this information will be useful for evaluation of toxicology tests on postmortem blood when determining cause of manner of death. If no significant differences of the data exist, then current standard methods of obtaining blood specimens and shipping specimens to reference toxicology laboratories will not need to be altered.

The estimated total budget for this 1 year project is $167,697.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K271

Kentucky State University

"Validity, Reliability, Accuracy and Bias in Forensic Signature Identification"

Principal Investigator:

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Funding Amount:

$466,710 for 2 years

Abstract:

Questions have been raised both in court and in a number of scholarly articles and treatises concerning the relatively small body of research supporting claims that forensic document examiners (FDEs) outperform jury eligible lay people in successfully identifying the source of questioned handwriting samples. Critics of forensic document examination also point out that the conclusions of FDEs may be biased due to the lack of blind review of examination results (see Saks & Vander Haar, 2005; Risinger, Denbeaux & Saks, 1989; Saks, 1989, 2003; Faigman, Kaye, Saks, Sanders & Cheng, 2006; Denbeaux & Risinger, 2003; Faigman, Kaye, Saks, & Sanders, 2003; Saks & Koehler, 2005).

Few empirical studies exist to support the validity and reliability of forensic document examination. However, little empirical research exists to refute its validity or reliability. Most of the extant studies have been criticized for their relatively small numbers of participants, lack of experimental control, or lack of structural verisimilitude. This research will address several of the most important areas of forensic document examination presently at issue in state and federal courts.

The proposed research uses a multi-modal approach to investigate the existence and nature of expertise related to forensic document examination, the evaluation and interpretation of the salient features of signature specimens, and the relationship between social influences inherent in the context of forensic document examination (e.g., information about prior examination outcome) on the outcomes of document examination.

The proposed study is relevant to the following areas of research: 1. Studies that examine the degree of accuracy and reliability of methods used by forensic scientists; 2. Research designed to further a full understanding of quantifiable measures of uncertainty in the conclusions of forensic analyses, regardless of source of uncertainty; 3. Research designed to develop new approaches to forensic analysis, including quantitation of analyses that are currently qualitative in nature; and 4. Research to examine human factors affecting forensic practice, including potential systemic errors.

A sample of 120 forensic document examiners will be asked to participate in a preliminary survey assessing the nature and extent of their education, training, and experience, and other credentials in the

field. They will also be asked to share their views about the present methods of FDE education and training.

Using the eye-tracking methodology employed by Dr. Dyer and Dr. Found in their previous research on visual attention in document examination, we will explore how FDEs and laypeople extract information from handwritten signatures.

Following the eye-tracking procedure we will also verbally elicit via semi-structured interviews information about examiners' and laypeople's opinions concerning the evidential value of the features within the signatures they evaluate. This combination of quantitative and qualitative information will allow us to quantitatively analyze the visual and cognitive steps that FDEs and laypeople employ to render decisions, and to obtain an understanding of the relationship between the kind and extent of evidential information contained in signature specimens and the accuracy of examiner and layperson decision making about the source of the questioned signatures.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K219

University of California-Davis

"Determination of Unique Fracture Patterns in Glass and Glassy Polymers"

Principal Investigator:

Mr. Frederic Tulleners
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Funding Amount:

$152,877 for 1.5 years

Abstract:

The study of fractures of glass and glassy type materials has been around for some time. It was mainly driven by the need to determine the various reasons for the failure of a brittle material. The studies of these materials are commonly described as fractography. Fractography is the means and methods for characterization of fractured specimens or components in order to study the mechanism of such failures. Over time, scientist and engineers have been able to formulated many theories and equations that postulate the reason and mechanism for such fractures. Currently, most of the engineering research articles that specialize in fractures, discuss the formation of fractures, analytical observations and they postulate that all fractures are unique. However, the focus on most literature is the explanation and mechanism of fractures. The ability to shows that each and every fracture is in fact unique has not been a matter of consequence or of interest to the engineering or scientific community. In contrast, the basis concept that fractures are unique and are not reproducible, is in fact, very relevant to the forensic science community. Only limited research using a few glass microscope slides has been conducted in this subject area. The conclusions are provided in a subjective manner which states that the fractures are unique. This study proposes to demonstrate the uniqueness of the fracture patterns of window glass, bottle glass, and plastic lens materials where the fractures are initiated under highly controlled conditions with the ultimate goal of objectively illustrating that each and every fracture forms unique fracture pattern.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K267

The Pennsylvania State University

"Improving the Understanding and the Reliability of the Concept of "Sufficiency" in Friction Ridge Examination"

Principal Investigator:

Dr. Cedric Neumann
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Funding Amount:

$479,412 for 2 years

Abstract:

Fingerprint comparison is one of the cornerstones of forensic crime investigation, and is recognized as an efficient means of personal identification.

Recently, Daubert and Frye hearings have brought to light the need for improving the understanding of the accuracy and reliability of friction ridge examination. The recent review of the state of forensic science in the United States by the National Research Council of the National Academies [1] has also stressed the need to develop quantifiable measures for methods that are currently qualitative in nature, such as the examination of fingerprints (and other impressions): current protocols and procedures to perform these examinations heavily rely on a succession of subjective decisions, from the initial acceptance of evidence for probative value to the final assessment of forensic results. The FBI/NIJ-sponsored Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST) defines these subjective decisions by a generic term [2,3,4]: Suitable (Sufficient): the determination that there is adequate quality and quantity of detail in an impression for further analysis, comparison or to reach a conclusion.

This research proposes to study the current accuracy, reliability and reproducibility of the determination of sufficiency for comparison and sufficiency for identification by fingerprint examiners; and proposes to develop training protocols, methods and quantifiable measures of sufficiency to supports operational decisions and source inferences made by examiners when comparing fingerprints. This research will rely on prior work funded by NIJ, by the Technical Support WorkingGroup (TSWG) of the U.S. Department of Defense [5,6,7] and by the Midwest Forensics Resource Center (MFRC). Building on the results of these past projects, this research aims to strengthen and render more transparent the scientific bases of fingerprint examination.

The research will benefit from three key elements, enablers to success and cost reduction:

(1) The project will rely and improve on already existing technology in part funded by NIJ, TSWG and MFRC;

(2) Extensive fingerprint (latent and control prints) datasets collected over the years during casework (sometimes mock casework) operations and other research projects will be used to support and validate the results of the study.
(3) A list of several hundreds of contact persons in the fingerprint community, who are willing to participate in studies strengthening the scientific bases of fingerprint comparison. This list originates from Langenburg's past and current studies (over 250 participants are currently taking part in a study funded by the MFRC – grant SC-10-339). This will provide an unprecedented sample size to study the reliability and reproducibility of the fingerprint examination process;

Profs Cedric Neumann and Christophe Champod, and Glenn Langenburg have expertise in the development, validation and implementation of statistical models for the evaluation of fingerprint evidence (as supported by the track record of publications in the area over the past 15 years [5-10]. Furthermore, the team has successfully delivered several complex technological projects to the U.S. government in the past years.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K221

Southwest Research Institute

"Reducing Uncertainty of Quantifying the Burning Rate of Upholstered Furniture"

Principal Investigator:

Dr. Marc Janssens
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Funding Amount:

$497,688 for 1 year

Abstract:

Upholstered furniture is involved in the majority of residential fires, either as the first item ignited or as a significant component of the fuel load. The reconstruction of residential fires therefore very often requires reliable estimates of the heat release rate of upholstered furniture. This is true regardless of whether a CFD code, a zone model, or another type of analysis is used.

Under ideal circumstances identical items as those involved in the fire are available. The necessary data can then be obtained from experiments in a furniture calorimeter and some small-scale tests. However, even in this case the test data are subject to uncertainty. The sources of this uncertainty include, for example, measurement errors and unknown ignition scenario.

It usually is not possible to obtain undamaged items for furniture calorimeter testing, but it is more likely that enough specimens are available for small-scale testing. The extent of small-scale testing that can be performed depends on the quantity of material that is available. If there is enough for Cone Calorimeter (ASTM E1354) tests, it may be possible to predict the burning behavior of the furniture item with reasonable accuracy. The accuracy of these predictions is strongly affected by the amount of testing that can be performed and by the measurement uncertainty and the predictive capability of the furniture model.

More often, there are no specimens available for Cone Calorimeter tests, but enough mater for Microflow Combustion Calorimeter (ASTM D 7309) tests. This calorimeter provides some information about the heat release charateristics of the material.

The worst case is when small-scale tests cannot be performed due to lack of funding, time, and/or test material.

The goal of this project is to develop guidelines for each of these situations on how to best estimate the burning rate of upholstered furniture and quantify/optimize the uncertainty of the predictions. The proposed approach consists of the following steps:

- Conduct a parametric study involving a series of ~70 room fire tests on upholstered furniture mockups to (primarily) quantify ignition scenario (including incendiary) and enclosure effects on the burning behavior of upholstered furniture.
- Conduct Cone Calorimeter and Microflow Combustion Calorimeter tests to obtain fire properties of the fabric and padding materials used in the construction of the mockups. This is expected to involve approximately 12 different materials (combinations).
- Based on the results of the parametric study and the small-scale tests, improve existing correlations and models to predict the heat release rate of upholstered furniture.
- Procure approximately 24 used chairs and sofas, perform a reduce number (since materials will be in limited supply) of the small-scale tests, and conduct room tests to measure the heat release of each item. Use FTIR to verify the composition of the upholstery of each item.
- Use the small- and full-scale test data on the used furniture (components) to validate the predictive methods resulting from the analysis of the mockup data.
- Develop guidelines on how to best estimate the heat release rate versus time curve of upholstered furniture and quantify/optimize the uncertainty of the predictions. The recommended approach will depend on the extent of the testing that can be performed.

The result obtained in this project will be compiled in a database for future fire investigator use. The video footage from this project can be used in the production of instructional DVDs.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K217

Oklahoma State University

"Improving Investigative Lead Information and Evidential Significance Assessment for Automotive Paint and the PDQ Database"

Principal Investigator:

Dr. Barry Lavine
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Funding Amount:

$460,473 for 2 years

Abstract:

Research will be undertaken to develop new pattern recognition techniques for searching infrared (IR) spectral libraries of the Paint Data Query (PDQ) automotive paint database. These search techniques will be used to differentiate between similar but nonidentical Fourier transform infrared (FTIR) paint spectra, and to determine the model, manufacturer, and year of the vehicle from which an unknown paint sample originated. Currently, modern automotive paints use thinner undercoat and color coat layers, which are protected by a thicker clear coat layer. As a result, only a clear coat paint smear is, all too often, left at the crime scene. In these cases, the text based portion of the PDQ database cannot be used to identify the motor vehicle. However, based upon our previous experience, clear coat paint layers, like the undercoat and color coat paint layers, exhibit chemical features in their FTIR spectra that are unique to the automobile manufacturing plant at which they were applied and so clear coat spectra may be used to identify the make, model, and year of a motor vehicle. The development of search prefilters and library searching algorithms for the PDQ database, which is the thrust of this research proposal, is needed to extract investigative lead information from a clear coat paint smear.

Searches performed using the current PDQ database tend to generate a large number of hits because the chemical information in the current database is described only in terms of generic chemical formulations. However, an added advantage of using the pattern recognition approach to identify paint samples will be an increase in accuracy because spectra from the entire database will be searched. Information derived from the proposed pattern recognition searches will serve to quantify the general discrimination power of original automotive paint comparisons encountered in casework, and will further efforts to succinctly communicate the significance of the evidence to the courts. Addressing these concerns is a direct response to Recommendation 3 of the National Academies' February 2009 report, "Strengthening Forensic Science in the United States: A Path Forward." To maintain relevancy of the newly designed pattern recognition techniques, development of data resident in the database will simultaneously be undertaken to populate it for production years where there is insufficient data. It is anticipated that once these pattern recognition techniques have been developed, they may also be used

to efficiently and accurately search other forensic spectral libraries, for example, illicit drug and pharmaceutical databases, textile fiber database and explosive databases.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K273

University of Central Florida

"Frequency Occurrence of Handwriting and Hand-Printing Characteristics"

Principal Investigator:

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Funding Amount:

$498,659 for 2 years

Abstract:

Forensic document examination has long held, as a basis for the discipline, no two people share the exact same set of handwriting characteristics. There have been numerous studies involving small groups of the general population and small sub-groupings of populations as to the uniqueness of handwriting and of frequency occurrence of characteristics. However, to date, there have been no large-scale studies involving a statistically appropriate sampling the overall U.S. population or sub-grouping. It is the purpose of this research project:

a. To develop statistically valid frequency ratios of characteristics of handwriting and hand printing based on specimen samples throughout the United States

b. To provide practitioners of forensic document examination with statistical basis for reliability and measurement validity to accurately state their conclusions

c. To provide courts with the reliable data needed to understand the underlying scientific basis for the examinations and the conclusions.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K215

The University of Tulsa

"Reliability of Forensic Data from Networked Process Control System"

Principal Investigator:

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Funding Amount:

$743,706 for 3 years

Abstract:

A physical system that is controlled by an array of logic devices interconnected through a communications infrastructure is effectively a networked process control system. Also known as cyber-physical systems, they are ubiquitous in American society and are used in applications ranging from medical devices, to automobiles, to robotics, to power distribution grids. Therefore, addressing the reliability of the forensic historical data from these systems requires formal mathematical and logical methods that transcend the specific application domains. While formal methods are broadly useful they may easily become intractable if not focused on specific domains or environments. However, their implementation in a computing environment, following established software engineering guidelines, will make them tractable for large-scale systems. Furthermore, developed tools will be validated by applying the methodology to a specific application of networked process control systems; namely, commercial vehicle event data recorders.

The proposed research methodology has three tiers that transverse from the abstract to the concrete. The foundational tier will incorporate a mathematical formalism based on the Tagged Stochastic Pi Calculus to model system behavior. The second tier involves creating simulation environments capable of capturing network behavior and evaluating the effects that communication protocols and network topology may have on a cyber-physical system. The application tier will focus on a customized toolset for the examination and evaluation of the reliability of forensic data obtained from cyber-physical systems in a commercial motor vehicle.

Modern commercial vehicles have Event Data Recorders (EDRs) that store relevant information about vehicle operation and other environmental variables. This information, typically stored in binary format, can become instrumental in supporting criminal investigations. Examples of criminal activity involving commercial vehicles include: speeding, manslaughter, aggravated homicide, drug trafficking, and even acts of terrorism. Therefore, preserving and extracting evidence contained in EDRs while being able to establish data integrity is paramount to any criminal prosecution.

Preservation of the digital record will be accomplished by developing systems capable of monitoring and logging digital communications with the EDR. An important component of the research plan focuses on

replaying component communications to emulate the EDR. This new "virtual EDR" will represent a verifiable forensic copy of the original data. The use of digital forensics tools, such as mathematical hashing, will be used to verify the original content of these forensic copies of the EDRs, i.e., to ensure that data integrity is preserved. Furthermore, the accuracy of the data on an EDR needs to be assessed through simulation to ensure understanding of timed measurements based on network data contained in the EDR.

While physical testing is important, it is cumbersome and expensive. Therefore, this research plan proposes the use of computer simulations to model and analyze the data reliability in EDRs. However, the simulation systems need to be developed using a rigorous and unambiguous language specification supported by a sound mathematical formalism. Hence, a tiered approach is needed to assess, with high levels of assurance, the reliability of commercial vehicle EDRs. Successful implementation has broad impact since the mathematical formalisms and simulation environment can be easily extended to other application domains.

This research will produce the following: (1) mathematical formalism and theorem proving environment for networked process control systems, (2) runtime substrates needed to simulate the inherent variations associated with networked PCS, (3) software tools to emulate the digital information on an EDR in a forensically sound manner, (4) prototype of low-cost hardware capable of extracting digital records from an EDR, (5) examination of the accuracy of the data recorded in EDRs based on physical and virtual testing, and (6) tools needed to evaluate the reliability of events from other networked process control system.

NIJ Point-of-Contact

Program Manager: Martin Novak

2010-DN-BX-K220

South Carolina Research Foundation

"Evaluation of Statistical Measures for Fiber Comparisons: Interlaboratory Studies and Forensic Databases"

Principal Investigator:

Dr. Stephen Morgan
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Funding Amount:

$489,049 for 1 year

Abstract:

This proposal involves a collaborative effort between three groups of forensic researchers in academic laboratories and forensic practitioners in three local/state forensic laboratories. The objectives of the proposed research include: (a) to conduct interlaboratory experiments to evaluate decision making in forensic fiber examinations by polarized light microscopy measurements, UV/visible microspectrophotometry, and IR spectroscopy; (b) to investigate the application of multivariate statistical measures for evaluation of comparisons of questioned (Q) vs. known (K) fibers; (c) to evaluate intra-laboratory variability, inter-laboratory agreement, and error rate performance in designed experiments; (d) to document good laboratory practices relevant to achieving acceptable levels of intra- and inter-laboratory consistency in fiber data; (e) development and use of a prototype forensic data management system for fiber examinations that will integrate electronic signatures for documentation on data stored, data validity checking, and relational database searching. The collection of over 500 dyed fibers at USC, previously acquired from textile companies, will be expanded to include additional fibers relevant to casework by consultation with the participating forensic laboratories. The interlaboratory studies will involve Q vs. K fiber examinations by all six laboratories of several hundred pairs of (blind-coded) fibers. Measurement uncertainties will be evaluated both within and between laboratories, and error rates associated with forensic match/no-match decisions will be compared. Multivariate statistical approaches including principal component analysis, cluster analysis, discriminant analysis, and multivariate analysis of variance will be employed to evaluate the statistical significance of differences between fibers, as well as of differences in measurement uncertainties for various measurements. Participation in the project by the three active forensic laboratories will provide

grounding in the practical applicability of the knowledge acquired. The improved understanding of sources of variability and decision-making processes gained from this research will advance the forensic significance of class evidence involving fiber examinations. Software developed for statistical discrimination will also be distributed for use by forensic service laboratories. The web-based database will promote dissemination of data, protocols, and statistics on fiber discrimination.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K223

Sam Houston State University

"Development and Quantitative Evaluation of Steganalysis and Digital Forgery Detection System"

Principal Investigator:

Dr. Qingzhon Liu
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Funding Amount:

$331,056 for 2 years

Abstract:

Steganography secretly embeds additional information in digital products, the potential for covert dissemination of malicious software, mobile code, or information is great. It can be used for a number of nefarious applications, including hiding records of illegal activity, financial fraud, industrial espionage, and communication among members of criminal or terrorist organizations, etc. (Hosmer 2006; Hosmer and Hyde 2003). To protect national security and combat cyberterrorism and cyber-crimes which exploit steganography tools, it is therefore crucially important to develop highly reliable and efficient methods to detect digital steganography on the Internet. Thus steganalysis, or steganography detection, has been an active research field in information security and digital forensics due to its great interest to law enforcement and national security. Meanwhile, as current technology allows today's ubiquitous digital media to be easily altered and manipulated, our traditional confidence in the integrity of these voluminous media has been eroding since doctored pictures, video clips, and audios are appearing with increasing frequency and sophistication in media outlets, scientific journals, political campaigns, and even courtrooms (Farid 2009). Over the past five years, digital forensics has emerged as a new, important, and challenging field. Multiple methods have been designed to authenticate digital media, which is critical for justice while these media are collected and presented in courts as digital evidences. The race between steganographers and digital media forgers, and their detectors is never ending. In this proposal, we intend to extend our prior work on steganalysis and forgery detection to rigorously examine the methods used by forensics scientist so that a more complete understanding of the scientific basis of digital multimedia forensics can be achieved. We also plan to develop quantifiable measures for reliability and accuracy of steganalysis and authentication of digital media evidence, to design new approaches by constructing quantification models, to introduce new measurement parameters to enhance the evaluation, to examine systemic errors, and to seek a full understanding of quantifiable

measures of uncertainty in the conclusions of forensic analyses towards complete evaluation, hence provide a good reference for the criminal justice community in policy and practice matters regarding digital forensics as related to steganography and forgery detection.

NIJ Point-of-Contact

Program Manager: Martin Novak

2010-DN-BX-K214

North Carolina State University

"Testing the Validity of Radiographic Comparisons in Positive Identifications"

Principal Investigator:

Dr. Ann Ross
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Funding Amount:

$284,763 for 3 years

Abstract:

Positive identification is of primary importance for case resolution and bringing closure to the victim's families. Difficulties surrounding the identification process can result from taphonomic processes that result in incomplete recovery of skeletal materials and/or from inadequate antemortem records. Therefore, a variety of identification methods that utilize various anatomical structures is essential for timely and accurate identification. While there are a number of methods used to make positive identifications through radiographic comparison, many lack the scientific rigor necessary to make them admissible in court.

To ensure admissibility, it is necessary for forensic anthropological research to conform to the Daubert criteria and the suggestions made in the NAS report. The proposed project will evaluate and quantify the degree of uniqueness exhibited by various anatomical structures visible in radiographs, test the accuracy and reliability of currently used methods, and determine error rates. The project will establish a standard system for making radiographic comparisons that is compliant with the Daubert criteria and the NAS report. This project will prove useful to the forensic science community as few quantitative methods for the comparison of antemortem and postmortem radiographs for the positive identification of deceased individuals currently exist. The proposed research will be conducted in order to address these issues, particularly as they apply to personal identification of unidentified remains using radiographic comparisons.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K213

Minnesota Department of Public Safety

"Reliability Measures for Current Methods in Bloodstain Pattern Analysis"

Principal Investigator:

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Funding Amount:

$602,578 for 3 years

Abstract:

Although Bloodstain Pattern Analysis (BPA) has been used in criminal investigations for many years, like many other disciplines from the early days of forensic science, its use and acceptance has occurred without rigorous validation. Testing the reliability of bloodstain pattern analysis methods is complicated by the fact that it is generally impossible to know with certainty the 'true' mechanistic cause of a bloodstain pattern. Such testing generally relies on creating artificial scenarios for which the 'true answer' can be known. Despite the limitations of such an approach, it is important to take steps towards understanding method reliability. The overall purpose of this study therefore is to establish some baseline data for the reliability of current pattern recognition methods of bloodstain pattern analysis. A panel of experienced bloodstain pattern analysts will be recruited and asked to classify a series of patterns covering a range of pattern types. A linear model for error rate will be derived from a multivariate analysis of variance collected in a balanced experimental design. Control of variables such as the substrate the pattern is made on, the extent of the pattern available for analysis and the provision of ancillary case information, will indicate the role of these variables in limiting the accuracy of pattern classification. The key deliverable of this study will be a quantifiable measure of the accuracy of pattern recognition for bloodstains under a range of conditions relevant to crime scene examination and forensic casework.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K212

Minnesota Department of Public Safety

"Development of Individual Handwriting Characteristics in ~1800 Students: Statistical Analysis and Likelihood Ratios that Emerge Over an Extended Period of Time"

Principal Investigator:

Ms. Lisa Hanson
lisa.hanson@state.mn.us

Funding Amount:

$399,172 for 3 years

Abstract:

The Minnesota Bureau of Criminal Apprehension (MNBCA) is proposing a study that would begin to answer requests from recent reports, including the NAS report published in February, 2009, for scientific research and studies in the pattern recognition sciences, in this case specifically, Forensic Handwriting Examination.

The MNBCA will gather large amounts of handwriting and hand printing samples in order to measure individual handwriting characteristics (departures from the instructed copybook style), using CEDAR-FOX software. After collecting the measurement data, it will be statistically analyzed for subsequent likelihood ratios of various individual handwriting characteristics in bodies of writing. It is believed that information developed from these likelihood ratios will begin to answer critical questions about the accuracy and reliability of Forensic Handwriting Examinations.

The first part of this study has been developed to cover a three year span. However, permission has been requested and granted by all the agencies and people involved, to work together for an eleven year study, providing the information retrieved from this study is as valuable as expected. By collecting handwriting samples over this extended period of time (up to 11 years in 3 year increments) this study will develop an extended database that will allow for time model analysis of the data collected that can be quantifiably measured and would lead to further understandings of the many complexities involved during the act of writing.

Forensic Handwriting Examinations are often an important part of criminal and civil investigations and court cases: Threatening letters, bomb threats, check fraud, homicides, and controlled substance cases, just to name a few. In addition, there is this large request for studies that provide scientific data about Handwriting Examinations from U.S. and International Judges, lawyers, academics and other practitioners. This study will statistically analyze data from handwriting samples collected during the development stage of individual handwriting characteristics and well into adulthood. This is important information that will provide a clearer scientific basis of what needs to be involved during a forensic

handwriting examination and it will also provide the statistical data that supports the conclusions reached from such examinations.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K269

Miami Dade County

"Miami-Dade Repeatability and Uniqueness of Striations/Impressions in Bullets Fired in 10 Consecutively Manufactured Glock EBIS Barrels"

Principal Investigator:

Dr. Thomas Fadul
tgfadul@mdpd.com

Funding Amount:

$23,896 for 2 years

Abstract:

The purpose of this proposal is to conduct an empirical study to evaluate the reproducibility and uniqueness of striations/impressions imparted to consecutively manufactured Glock Enhanced Bullet Identification System (EBIS) Barrels with the same EBIS pattern, as well as to determine the error rate for the identification of same gun evidence. The Miami-Dade Police Department (MDPD) Crime Laboratory (CL) is proposing "The Repeatability and Uniqueness of Striations/Impressions on Spent/Fired Bullets Fired in 10 Consecutively Manufactured Glock Enhanced Bullet Identification System (EBIS) Barrels" as a project for funding in the amount of $23,895.50 from the Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines Grant Program. The foundation of firearm and tool mark identification is that each firearm/tool produces a signature of identification (striation/impression) that is unique to that firearm/tool, and through the examination of the individual striations/impressions, the signature can be positively identified to the firearm/tool that produced it. The National Academy of Sciences (NAS) Report questioned the repeatability and uniqueness of striations/impressions left on fired evidence as well as the validity and error rate in firearms identification. The MDPD has been researching/evaluating the Glock barrel since 1994. The Glock EBIS barrel is a polygonal barrel, which has a bar code like pattern added to it during the manufacturing process. This study will analyze the repeatability and uniqueness of striations/impressions on spent/fired bullets fired in 10 consecutively manufactured Glock EBIS barrels with the same EBIS pattern by analyzing their striations/impressions. One semi-automatic pistol and nine additional barrels will be purchased from Glock Inc. Consecutively manufactured EBIS barrels with the same EBIS pattern are significant to the study because these barrels will be manufactured with the same equipment/tools and exhibit the same EBIS pattern. Even though these barrels are consecutively made, their signatures should still be different. Test sets will be assembled which will include test fired bullets from each barrel as well as unknowns. Participants will be firearm & tool mark examiners throughout the United States. This research study will provide an error rate for the identification of same gun evidence that will be calculated by an independent statistician from a local academic institution. The results of this study will also provide test documentation of the following two research questions:

1. Will firearm and tool mark examiners be able to identify unknown bullets fired through consecutively manufactured Glock EBIS barrels to the firearms that fired them utilizing individual, unique and repeatable striations/impressions?
2. Will the experience level of firearm and tool mark examiners affect results when examining bullets fired through consecutively manufactured Glock EBIS barrels?

This fundamental research will improve understanding of the accuracy, reliability and validity of the forensic science discipline of firearm and tool mark identification.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K268

Miami Dade County

"Miami-Dade Research Study for the Reliability of ACE-V Process: Accuracy, Precision, Reproducibility and Repeatability in Latent Fingerprint Examination"

Principal Investigator:

Mr. Glen Calhoun
Hgc_mdpd@hotmail.com

Funding Amount:

$139,530 for 2 years

Abstract:

The Miami-Dade Police Department (MDPD) Forensic Services Bureau (FSB) is proposing a "Research Study for the Reliability of the ACE-V Process: Accuracy, Precision, Reproducibility and Repeatability in Latent Fingerprint Examinations" as a project for funding in the amount of $139,529.70 from the Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines Grant Program. The foundation of latent fingerprint identification is that friction ridge skin is unique and permanent. Through the holistic examination of all of the qualitative and quantitative features available in friction ridge skin, impressions can be positively identified to the individual that produced it. In the National Academy of Sciences (NAS) Report, Strengthening Forensic Science in the United States: A Path Forward, the NAS states that "there are two very important questions that should underlie the law's admission of and reliance upon forensic evidence in criminal trials: (1) the extent to which a particular forensic discipline is founded on a reliable scientific methodology that gives it the capacity to accurately analyze evidence and report findings and (2) the extent to which practitioners in a particular forensic discipline rely on human interpretation that could be tainted by error, the threat of bias, or the absence of sound operational procedures and robust performance standards." This study will evaluate the reliability of ACE-V methodology by measuring the accuracy, precision, reproducibility and repeatability of four categorical opinions: identification, exclusion, inconclusive, and no value. In this study, 100 test sets will be assembled from 320 latent impressions and 13 standards. Test sets will require the comparison of unknown latent impressions to known standards in three phases. Participants will be Latent Fingerprint Examiners throughout the United States.

The results of this study will provide statistical data for the following five research questions. All statistical data will be calculated by an independent statistician from a local academic institution.

1) Will Latent Examiners be able to correctly identify or exclude unknown latent impressions from known standards using the ACE methodology?
2) Will Latent Examiners be able to correctly identify or exclude unknown latent impressions from known standards using the ACE-V methodology?

3) Will Latent Examiners reach significantly varied conclusions when comparing unknown latent prints to known standards using the ACE and ACE-V methodology?
4) Will Latent Examiners be able to reproduce and repeat conclusions from unknown latent impressions to known standards using the ACE and ACE-V methodology?
5) Will Latent Examiners be able to reproduce and repeat conclusions from unknown latent impression to known standards using the ACE-V methodology under high bias conditions?

This fundamental research will improve the understanding of the accuracy, reliability, and validity of the forensic science discipline of latent fingerprint examination.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K272

Marshall University Research Corporation

"Interpretation of Ignitable Liquid Residues in Fire Debris Analysis: Effect of Competitive Adsorption, Development of an Expert System and Assessment of the False Positive/Incorrect Assignment Rate"

Principal Investigator:

Dr. John Graham Rankin
rankinj@marshall.edu

Funding Amount:

$540,752 for 2 years

Abstract:

The focus of the proposed research will be three-fold: (1) To assess the effect of competitive adsorption of specific components of by various charred substrates routinely found in fire debris when employing the ASTM E1412 (Separation of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Activated Charcoal) which can lead to an incorrect interpretation of the results from E1618 (Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry); (2) Development of an expert system to interpret chromatograms obtained from Gas Chromatography- Mass spectrometry analysis of ignitable liquid residues (3) Statistical evaluation of the false positive and false negative rates by fire debris analysts and the expert system following E1618 at low levels of ignitable liquids in fire debris samples.

Although the effect of competitive adsorption of ignitable residues on activated charcoal known for many years [1], only recently has the effect of competitive adsorption by charred debris been shown (with a limited number of substrates) to potentially affect the interpretation of the results [2]. This initial study showed that some aromatic hydrocarbons present in gasoline and normal hydrocarbons (nHC's) found in kerosene and diesel fuels especially for charred pine substrates. In our lab we have seen a similar, though less pronounced, for a significant decrease in apparent nHC's in kerosene samples from burned samples with wood and carpet pad [3]. A systematic investigation will be undertaken to better understand the effects of substrate, degree of charring, ignitable liquid class and quantitative level of ignitable liquid on the interpretation of the ignitable liquid class according to the E1618 methodology.

Because E1618 is basically a visual pattern matching method, it is, by nature, subjective. Automated methods using neural networks and multivariate statistics have been reported to reduce the subjective nature of the interpretation [4-9]. An expert system will be developed using samples from the Ignitable Liquid Residue Collection (maintained by NCFS, U. Central Florida) and from our own collection of over 1000 ignitable liquids with simulated fire debris using a variety of substrates following E1412 [10] and E1618 [11] methodology.

The National Academy of Science report specifically addresses the need for determination of false positive determinations of pattern evidence [12]. This is particularly important at low levels of ignitable residue in the fire debris where interpretation is more difficult [13]. Substrates that pyrolyze to compounds resembling ignitable liquids further complicate interpretation [16-20]. We propose to create a series of "case files" of GCMS chromatograms with total ion chromatograms (TIC) and extracted ion profiles (EIP) as prescribed by E1618 from low level spiked and comparison samples on charred and uncharred substrates. These case files will be distributed to a number of experienced fire debris analysts solicited from the forensic community for 'case review' in a 'round robin' format. The Fire Debris Analysis Discussion Group (meets annually at AAFS national meetings and includes, state, local, federal and private fire debris analysts) and other fire debris analysts will be solicited for participants. Each analyst would be asked to make a determination for each case file according to his/her agency's guidelines: 1. Is an ignitable liquid present? 2. If present, to which E1618 class does it belong? The results will be evaluated statistically for False Positive Rate and Rate of Incorrect Assignment. Anonymity of the responses will be maintained. These same profiles in electronic form will be used to test the reliability of the expert system developed and compared to the results from the fire debris analysts.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2010-DN-BX-K218

Hughes Associates, Inc

"Electrical Fires' Forensic Signatures of Fire Cause Events"

Principal Investigator:

Dr. Daniel Gottuk
dgottuk@haifire.com

Funding Amount:

$325,715 for 1.5 years

Abstract:

The proposed research will perform fundamental research to better understand the accuracy and reliability of potential signatures of electrical fires. The work will provide a quantitative basis for validating the utility of diagnostic forensic tools discussed in the literature. The work will determine the required conditions that are needed for ignition and the subsequent forensic signatures that can be used to differentiate whether the electrical component was the cause of the fire or a victim of the fire. The project will focus on receptacles, plugs and cords with AC power. Completion of the project will improve the practice of fire investigation by providing a technical basis for realistic electrical fire scenarios, improving fire scene interpretation, and evaluating the utility of forensic analysis techniques.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

2008-IJ-R-134

UT-Battelle and Oak Ridge National Laboratory

"Investigation of a Novel Approach to Forensic Analysis Using Neutron Imaging Techniques"

Principal Investigator:

Dr. Hassina Bilheux
bilheuxhn@ornl.gov

Funding Amount:

$499,261 for 3 years

Abstract:

Living organisms consist mainly of the six basic elements: C, H, O, N, P, and S. These elements are combined to form the four major classes of biological macromolecules found in living matter: proteins, nucleic acids, polysaccharides, and lipids. After death, tissue undergoes sequential changes consisting of organic and inorganic phase variations, as well as a gradual reduction of tissue water content. While carbon dominates the chemistry of biological tissues, hydrogen atoms are the most abundant element. Hydrogen nuclei scatter thermal and cold neutrons more strongly than any other atomic nucleus. These two facts ensure that hydrogen is the primary contributor to neutron contrast in biologic specimens. The principle of neutron imaging is based on the attenuation, both scattering and absorption, of a directional neutron beam by the matter through which it passes. Neutron imaging is complementary, rather than competitive with X-ray imaging. Since x-rays are scattered and absorbed by the electrons, the attenuation increases monotonically with atomic number. Neutrons interact with atomic nuclei, and their attenuation does not scale in a regular way with atomic number. Thus, unlike other imaging methods, neutrons are strongly attenuated by hydrogen (the predominant elemental constituent of biological materials) which is manifest as contrast in an image. These contrast differences in neutron scattering and imaging can readily be applied in a forensic context to determine small changes in hydrogen concentrations. Since human decomposition starts approximately 4 minutes after death, structure and hydrogen concentrations change with time. We propose to study the decomposition of fresh animal tissues (for example, deep muscle tissue and bone with bone marrow) and frozen human tissues using neutron imaging techniques as a method to estimate the time of death. Since neutrons have yet to be used for forensic research, a broad selection of tissue samples is required to investigate which tissues will best show changes in neutron contrast due to hydrogen concentration changes and the structural changes of the tissue. In addition, we will investigate the effect of different environmental conditions (temperature and humidity) to simulate a corpse exposed to the elements. Neutron imaging data will be collected on tissues from fresh to several days of exposure. These results will be compared to imaging techniques commonly used in forensic research such as histology with light microscopy, microCT, and X-ray imaging.

In conclusion, the main hypothesis of our study is that as the hydrogen content of degrading tissue changes in time, neutrons can quantitatively measure changes in the hydrogen content of the tissues and identify structural changes as they happen through time. Hence, models may be built to determine more accurately the time of death for human beings and adjust for the environment to which they were exposed. Results of this research will be disseminated through peer-reviewed publications, presentations, training classes, and required reports.

NIJ Point-of-Contact

Program Manager: Gerald LaPorte

#5. Forensic DNA Research and Development

Posting Date: February 1, 2010

Closing Date: April 2, 2010

Awards Made: 18

With this solicitation, NIJ sought applications for research and development that can enhance the forensic uses of DNA technology. This solicitation focused on the development of tools and technologies that will allow faster, more robust, more informative, less costly, or less labor-intensive identification, collection, preservation, and/or analysis of biological evidence that has the potential for DNA Analysis.

The specific areas of research include:

- General improvements to the "front end" of the forensic DNA analysis process.
  - Development of rapid screening methods for use at crime scenes to help assess the probative value of biological materials.
  - Development of non-/minimally destructive methods for biological evidentiary sample identification and/or collection.
  - Development of improved tools (e.g., substrates, devices, methods) for biological evidence preservation and/or storage. The tool must effectively maintain the integrity of the sample, and efficiently and consistently release the sample for subsequent analysis.
  - Development of non-/minimally destructive methods for DNA extraction.
  - Development of genetic screening methods for assessing probative value of evidentiary samples. This method could help crime laboratory analysts to focus the full analysis on the most probative samples, thus reducing the time currently spent on interpretation and reporting of samples that are non-probative.
- Physical separation of cells (sperm cells from female epithelial cells, epithelial cells from different sources, etc.) or other components (e.g., polymerase chain reaction [PCR] products) in mixtures from two or more individuals or sources.
- Identification and/or characterization of biological markers that have the potential to reveal additional or more powerful information about the source of the biological evidence.
- Improved tools for examining aged, degraded, limited, damaged, inhibited, or other compromised DNA evidence.
- Novel approaches for genetic profiling.
- Identification and/or characterization of genetic marker systems that have the potential to advance the tools available for forensic pathology examinations.
- Development of new or enhancement of existing population data for use in estimating frequencies of genetic markers used in forensic applications.

FY 2010 Forensic DNA R&D Awards

Grant Number	Grantee	Title	Page #
2010-DN-BX-K190	Board of Regents University of Wisconsin	Tools for improving the quality of aged, degraded, damaged, or otherwise compromised DNA evidence	Pg. 179
2010-DN-BX-K193	Bode Technology Group, Inc	Effective Long-Term Preservation of Biological Evidence	Pg. 181
2010-DN-BX-K204	Florida International University	Detection and remediation of PCR inhibition using real time PCR melt curves as a diagnostic tool.	Pg. 182
2010-DN-BX-K224	Michigan State University	Trace DNA from Fingernails: Increasing the Success Rate of Widely Collected Forensic Evidence	Pg. 183
2010-DN-BX-K171	Western Carolina University	Assessing Deep Sequencing Technology for Human Forensic mitochondrial DNA	Pg. 184
2010-DN-BX-K209	Akonni Biosystems Inc.	A Microfluidic Microarray Instrument to Type SNPs for Physical Appearance	Pg. 185
2010-DN-BX-K191	Bode Technology Group, Inc	Targeted Non-Destructive Evidence Detection and Collection	Pg. 186
2010-DN-BX-K141	Children's Hospital & Research Center at Oakland	Resolution of DNA Mixtures and Analysis of Degraded DNA Using the 454 DNA Sequencing Technology	Pg. 187
2010-DN-BX-K230	County of Harris	Genetic Markers Associated with Sudden Unexplained Death or Sudden Infant Death	Pg. 189
2010-DN-BX-K192	NY City Office of Chief Medical Examiner	Development of a Proteomic Assay for Menstrual Blood, Vaginal Fluid and Species Identification	Pg. 190
2010-DN-BX-K228	The University of Tennessee	Evaluating the Use of DNA and RNA Degradation for Estimating the Post-Mortem Interval	Pg. 192

2010-DN-BX-K190

Board of Regents University of Wisconsin

"Tools for improving the quality of aged, degraded, damaged, or otherwise compromised DNA evidence"

Principal Investigator:

Dr. Michael Cox
cox@biochem.wisc.edu

Funding Amount:

$999,825 for 3 years

Abstract:

This project seeks to answer a single question. Can DNA evidence that has been deemed quantitatively and qualitatively inadequate for PCR-based genotyping be restored to a usable condition if pre-treated with mixtures of DNA repair proteins?

Due to age, environmental exposure, fire or other damaging conditions, many forensic DNA samples cannot currently be analyzed using existing STR genotyping protocols. The problems are typically related to DNA damage, including DNA lesions of many kinds. However, DNA double strand breaks represent the major and most common barrier to successful STR analysis. A successful repair protocol would greatly enhance the reach of current forensic DNA technologies.

We are proposing to complete the development of a procedure for the repair of heavily damaged forensic DNA samples. Work carried out under a previous grant from the National Institutes of Justice (2007-DN-BX-K145) led to the development of a robust in vitro method for the repair of DNA double strand breaks. In brief, targeting DNA strands are used to replace DNA sequences on either side of an STR locus, using a cocktail of the bacterial RecA protein, SSB, and DNA polymerase I. A provisional patent was submitted in 2009, and a full patent will be filed soon.

The proposed work will take our already robust in vitro double strand DNA break repair reaction, and reduce it to practice on forensic DNA samples. Further increases in reaction efficiency will be explored. The repair process is relatively simple, requiring only three proteins, and is easily automated. It can be used as an upstream treatment of samples, which would then be processed normally by standard STR analysis protocols. It is carefully designed so as not to affect the STR signal. The reaction requires no enzymes, such as nucleases, that could further damage a forensic DNA sample. Reagents are being developed to allow the targeted repair of all CODIS STR loci as well as other STR loci used in standard commercial multiplex kits.

All work will be carried out within an ongoing collaboration between the laboratories of Michael M. Cox (University of Wisconsin-Madison), John R. Battista (Louisiana State University), and Elizabeth A.

Thompson of the Orange County (CA) Crime Laboratory. Early work stages will focus on protocol optimization and screens to achieve demonstrable repair of standardized test samples of human DNA (already in hand). The optimized protocol will eventually be applied to evidence archived from several decades-old cold cases in Orange County, CA.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K193

Bode Technology Group, Inc

"Effective Long-Term Preservation of Biological Evidence"

Principal Investigator:

Dr. Robert Bever
Robert.bever@bodetech.com

Funding Amount:

$353,186 for 1 year

Abstract:

The preservation of biological evidence is necessary in order to maintain the quality and quantity of valuable DNA for forensic casework analysis. Once evidentiary material (blood, semen, vaginal fluid, etc.) is collected on a substrate, it is subject to degradation by nucleases from environmental microbes as well as oxidation from environmental forces. This presents a problem as some evidence may be stored for months or even years before a crime lab receives it for analysis. Many current forensic evidence collection substrates (swabs, cloth, etc.) do not include methods for DNA preservation. The goal of this project is to identify the optimum method to preserve DNA associated with associated with forensic evidence using commercial off the shelf chemical preservatives. We propose to conduct this study in 1 year, divided into two phases. Phase I will consist of a real-time and accelerated aging study that tests nine chemical preservatives individually. During phase II and after the accelerated aging results of phase I are evaluated, the preservatives with the most promising results will be combined to examine whether this will enhance the effects.

Commercial off the shelf (COTS) preservatives used for decades in the food and cosmetics industries may have direct applications for forensic practices to preserve biological evidence. These COTS preservatives are very inexpensive and safe, and could easily be applied to the cotton swab by the forensic investigator at the crime scene. We propose to test three main categories of chemical preservatives: antimicrobial agents, chelators/fixatives, and nuclease inhibitors. The ability to apply a DNA preservative directly to the swab would eliminate the risk of DNA degradation and could result in full profiles, rather than partial profiles, or increased peak height values of analyzable alleles. Once completed, the results of the study will be thoroughly disseminated throughout the forensic community through peer review publication and oral presentations.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K204

Florida International University

"Detection and remediation of PCR inhibition using real time PCR melt curves as a diagnostic tool"

Principal Investigator:

Dr. Bruce McCord
mccordb@fiu.edu

Funding Amount:

$294,800 for 2 years

Abstract:

In 2007 we began working on an NIJ sponsored project to examine and characterize mechanisms for degradation and inhibition of DNA samples. The goal of our previous proposal was to develop better methods to understand the underlying mechanisms for allele dropout in forensic DNA casework. One of our important findings was that we could use a Sybr green qPCR procedure to categorize and assess a wide variety of PCR inhibition through efficiency measurements and melt curve effects. Unfortunately at that time, few people had access to melt curve information as the TaqMan based Quantifiler Human assays did not permit measurement of DNA melt curves.

Recently, Promega has released a real-time PCR kit known as Plexor HY, which permits the use of melt curves. The goal of this proposal to examine the capability of the Plexor system to assess and identify classes of inhibitors a priori through the use of melt curve effects. We will also look at ways to enhance the capability of Plexor to detect inhibition. To do this we will modify the chemistry of the reaction mixture by removing BSA to enhance detection of inhibitory effects. Since our previous work has shown that currently used internal positive control DNA is very poor at detecting inhibition, we will also work to develop better IPC probes that are more efficient at detecting inhibitors that bind DNA. Using this data we will categorize various inhibitors based on their effect on amplification of Identifiler and Powerplex 16. Once we have defined set of inhibitors based on their mechanism, we will assess various methods to relieve inhibition including sample dilution, spin filtration, and magnetic bead based extraction. A table defining best practices for each class of inhibitor will be created based on these results.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K224

Michigan State University

"Trace DNA from Fingernails: Increasing the Success Rate of Widely Collected Forensic Evidence"

Principal Investigator:

Dr. David Foran
foran@msu.edu

Funding Amount:

$132,046 for 1.5 years

Abstract:

Direct contact between an assailant and victim occurs during sexual assault and many other violent acts. As the victim attempts self defense, biological material from the assailant may be left, particularly under fingernails. Owing to this, fingernails or material beneath them are regularly collected by forensic nurses, other emergency personnel, and pathologists from surviving or deceased assault victims for subsequent DNA testing. Unfortunately, very little is known about the utility of such collections, including if the existing methods for obtaining and testing fingernail/DNA evidence are optimal for producing probative evidence. In consultation with several forensic practitioners who collect and analyze DNA from nail evidence, a research regimen is proposed to address these questions in an objective and statistically reliable manner. Multiple methods for collecting nail evidence for subsequent DNA analysis will first be compared. Along with this, the various DNA analysis procedures widely used in crime laboratories (STRs, miniSTRs, YSTRs) will be considered, producing an optimal collection and analysis strategy for exogenous nail DNA. Finally, these procedures will be used on more nail evidence to determine if it is being collected in the most informative way. The ultimate goals of the proposed research are to: (1) determine the best method for isolating foreign DNA from nail evidence; (2) determine what type of genetic testing of nail evidence is most informative; and (3) determine if the way nail evidence is currently treated can be improved. The research is designed to be thorough, efficient, and informative, and should be of broad, practical use to the great number of forensic scientists who encounter fingernail evidence every day

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K171

Western Carolina University

"Assessing Deep Sequencing Technology for Human Forensic Mitochondrial DNA"

Principal Investigator:

Dr. Mark Wilson
mrwilson@wcu.edu

Funding Amount:

$397,098 for 2 years

Abstract:

Challenging forensic DNA samples extracted from, for instance, bones and hair can be degraded and/or contain very little DNA. Mitochondrial DNA (mtDNA) analysis is often utilized on these kinds of samples. Studies employing newly emerging DNA sequencing technologies have been designed to interrogate targets down to the single molecule level. Such studies have shown tissue differences (heteroplasmy) within individuals that have lead to recent public calls for a re-evaluation of current interpretational approaches to forensic mtDNA comparisons.

Human mitochondrial DNA analysis, in a forensic setting, is currently limited in both breadth (the amount of sequence data obtained) and depth (the ability to detect minor variants arising from mutations but present at very low levels). Using emerging technologies, an extension of the breadth of sequence data obtained can easily extend to the entirety of the human mtDNA genome. Extension in the complementary dimension (depth) will reveal subtle mixtures that are currently not detected by forensic DNA laboratories. Hence, new DNA sequencing technologies have the promise of providing information in both of these dimensions and thereby expanding the utility of mtDNA analysis in forensic science.

In the proposed effort, we will evaluate two newly emerging methods of DNA sequence analysis to obtain massively parallel mtDNA sequence information (deep sequencing) from hair, buccal, and blood samples. The expanded information available from deep mtDNA sequence analysis will reveal whether or not interpretational changes in forensic mtDNA analysis of such samples are necessary, as well as the extent to which deep sequencing can offer a window into a level of variation that is currently underappreciated in forensic casework. This effort will also reveal the general level of sequence heteroplasmy present in hair samples as compared to blood and buccal samples, all common targets of forensic mtDNA analysis.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K209

Akonni Biosystems Inc.

"A Microfluidic Microarray Instrument to Type SNPs for Physical Appearance"

Principal Investigator:

Dr. Phillip Belgrader
pbelgrader@akonni.com

Funding Amount:

$499,198 for 1 year

Abstract:

This project will be Phase III of previous NIJ funded work.

The goal of this work is to assemble and test a four-site (i.e., four sample cartridges operating in parallel) integrated microfluidic controlled microarray system for SNP-based typing of phenotypic markers. In Phase I, we demonstrated feasibility of Akonni's sample preparation, PCR, and gel drop microarray components as a complete solution for forensic SNP-typing applications. Components were packaged into prototype flowthrough, microfluidic modules to demonstrate SNP discrimination on forensic samples. In the current Phase II, we are optimizing protocols and assay chemistries for phenotype determination, and packaging components and reagents into a prototype integrated system for automated, sample-to-answer results. This system consists of the instrument (i.e., liquid handling, Akonni Bladder Thermal Cycler, Akonni Reader, and cartridge docking station) and a disposable, integrated cartridge (i.e., Akonni TruTip, Akonni PCR and TruArray flow cell chambers, microfluidic circuits, and microfluidic valves). Phase III will upgrade the current Phase II breadboard prototype from accepting a single cartridge to processing four cartridges in parallel. The system will be further refined into a commercial-ready alpha unit for early adopter evaluation.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K191

Bode Technology Group, Inc

"Targeted Non-Destructive Evidence Detection and Collection"

Principal Investigator:

Dr. Robert Bever
robert.bever@bodetech.com

Funding Amount:

$348,175 for 1 year

Abstract:

The ability to successfully detect, collect, and process individual biological samples from various evidence substrates without causing integral surface damage continually proves to be a difficult challenge in the field of forensics. Traditional techniques are effective liberators of biological samples but they do typically leave evidence items in an altered and/or damaged state and therefore are not universally applicable in all forensic inquiries. In response to this need, Bode Technology proposes to perform thorough evaluations of several novel non-destructive DNA collection tools: the Electrostatic Detection Apparatus (ESDA), Alternative Swab matrices, Adhesive Evidence Lifters, and various microfiber blends. The ESDA is a highly utilized document examination tool that may be a viable option for collecting DNA samples from evidence items due to the usage of electrostatic charge and vacuum polymer application. It is possible that various unconventional dry Alternative Swab matrices can be used to collect and release DNA more efficiently during the sampling and extraction process when compared to cotton swabs. Adhesive Evidence Lifters present a novel non-destructive collection alternative that in studies has efficiently collected evidence samples while leaving a substrate surface relatively unmarked. The unique star-shaped fibers of microfiber show great potential for use as a collection material as they have superior absorbing qualities and are able to collect and release trace particles with higher efficiency than cotton fibers. Each of these innovative DNA collection methods have shown positive results in preliminary experiments and if developed successfully would afford forensic scientists the ability to gain more information from sensitive evidence type items by allowing multiple full-scale examinations to be performed. These proposed non-destructive DNA collection methods would provide familiar and affordable alternatives in the forensic laboratory.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K141

Children's Hospital & Research Center at Oakland

"Resolution of DNA Mixtures and Analysis of Degraded DNA using the 454 DNA Sequencing Technology"

Principal Investigator:

Dr. Cassandra Calloway
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Funding Amount:

$699,230 for 2 years

Abstract:

Degraded and mixed DNA samples are often encountered in forensic cases and pose interpretation challenges. Alternative markers such as nuclear bi-allelic SNPs and mtDNA are often used to analyze limited and/or degraded DNA. However, there are some limitations to these approaches. Nuclear bi-allelic SNP markers do not allow for efficient detection of mixtures and mtDNA lacks discrimination power. While STR and mtDNA markers allow for detection of mixtures, they do not allow for separation of components in a mixture. Other approaches allow for physical separation of various cellular components or DNA molecules. However, these approaches may not completely separate components or be compatible with standard lab work flows.

The 454 DNA sequencing technology is a scalable, highly parallel pyrosequencing system that can be used for de novo sequencing of small whole genomes or direct sequencing of DNA products generated by PCR. The technology uses emulsion PCR (emPCR) to amplify a single DNA sequence to 10 million identical copies. The "clonal sequencing" aspect of the technology enables separation of individual components of a mixture as well as analysis of highly degraded DNA. The 454 DNA sequencing technology has been successfully used to analyze mixtures in clinical samples and for analysis of highly degraded DNA from "ancient DNA" samples, including an ~40,000 year old bone fragment. These studies demonstrate the potential utility of using the 454 sequencing technology for forensic applications.

We propose to use a 'front-end' PCR based approach which uses multiplex identification (MID) tags to amplify mtDNA and STR targets prior to emPCR. This 'front-end' approach is especially useful for sequencing specific target regions in the genome and allows for massive parallel sequencing of pooled samples. The 'front-end' mtDNA and STR assays will be used with the 454 DNA sequencing technology to separate components of a DNA mixture and to analyze limited or degraded DNA samples. Our primary goals are to 1) to develop and optimize a "front-end" multiplex PCR system for sequencing both nuclear STR and mtDNA markers using the 454 sequencing technology and 2) validate and apply the next generation sequencing assay to forensically relevant samples and populations. Our primary objectives are to 1) develop and optimize a "front-end" 454 mtDNA targeting minimally 15 polymorphic regions including the entire non-coding reigon and covering ~20-30% of the entire genome, 2) develop and optimize a "front-end" 454 miniplex STR system, 3) determine the sensitivity and detection limits of the

assay, 4) apply the system to forensically relevant samples and population groups, 5) modify existing next generation sequencing software for mtDNA and STR analyses, and 6) present and publish results as acquired as well as provide a demonstration of the technology to a local forensic laboratory.

The 454 DNA sequencing technology will allow the practitioner a start to finish method for sequencing mtDNA and mini STRs in a single run and analysis of mixed and degraded DNA samples. A new cheaper 454 GS Junior instrument is now available making access to next generation sequencing more attainable to forensic laboratories. The 454 genome sequencing technology can be readily integrated into the standard lab work flow and be used independently or in conjunction with standard STR or mtDNA assays. The proposed 454 mtDNA and STR assay is an ideal system with high sensitivity, resolution and discrimination potential for analysis of degraded or mixed samples commonly encountered in forensic cases and would therefore provide forensic laboratories with a low cost alternative to standard forensic assays.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K230

County of Harris

"Genetic Markers Associated with Sudden Unexplained Death or Sudden Infant Death"

Principal Investigator:

Dr. Roger Kahn
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Funding Amount:

$254,521 for 2 years

Abstract:

We propose to develop, validate and implement a DNA sequencing array system specific for genes linked to Sudden Infant Death Syndrome (SIDS) and Sudden Unexplained Death (SUD) in children and young adults. In the United States each year, there are thousands of sudden deaths of infants and young adults for which the cause of death is listed as undetermined, that is, no cause is identified during autopsy. The Harris County Institute of Forensic Sciences alone lists 750 unexplained deaths, classified as SIDS or SUD, since 2000. It is estimated that as many as 10% of the SIDS cases and approximately of 30% of the SUD cases can be linked to mutations in genes of cardiac function. In collaboration with the Baylor College of Medicine Human Genome Center, a tool based on second generation Roche 454 sequencing, will be developed and validated. This tool will sequence DNA from 27 genes implicated in SIDS or SUD and, upon validation, be implemented to test the Harris County Institute of Forensic Sciences cohort. Traditional sequencing methods are available to sequence 19 of these genes, however it is prohibitively expensive (approximately $18,900 per sample) and time consuming, requiring hundreds of PCR and sequencing reactions per case. Applying second generation DNA sequencing tools will reduce the cost per sample to less than $1000 and reduce the amount of work needed since PCR is not required prior to sequencing.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K192

NY City Office of Chief Medical Examiner

"Development of a Proteomic Assay for Menstrual Blood, Vaginal Fluid and Species Identification"

Principal Investigator:

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Funding Amount:

$418,824 for 2 years

Abstract:

From the work of our previous NIJ grant (Establishment of a Fast and Accurate Proteomic Method for Body Fluid/Cell Type Identification, 2008-DN-BX-K011) we developed a single, confirmatory body fluid assay capable of simultaneously identifying blood, saliva and semen from pure or mixed samples with greater sensitivity and specificity than other methods currently available. The underlying principle of this method is that each body fluid is composed of a distinct group of unique or highly enriched proteins that together constitute a "protein fingerprint" that can be used to identify, and distinguish, one body fluid from another. Three aspects of this technique recommend it over others. First, it is a single test capable of identifying all body fluids simultaneously thus eliminating the need to guess which test to perform on unknowns, as well as the need for multiple sequential tests that consume both time and sample. Second, the assay does not rely on a single protein for identification, thus giving greater confidence to the test and reducing confounding results which can occur when one body fluid marker is present in second body fluid (e.g. PSA in blood). Third, and importantly, the use of mass spectroscopy to determine peptide sequences, as opposed to antibody-antigen reactions which are an indirect method of protein detection with a variety of inherent pitfalls, raises the rigor and confidence of body fluid testing to a level similar to DNA analysis.

As part of our original application we proposed to establish similar protein fingerprint assays for menstrual blood and vaginal fluid based on the presence of mRNA candidate markers that had been described in the literature. Unfortunately, proteins for those RNA markers were not detected. However, during the course of our research we identified several protein candidates for menstrual blood and vaginal fluid that seem promising for establishing fingerprints assays for both of these body fluids. In addition, our research revealed that body fluids possess other important forensic information that is easily, but rarely, extracted during body fluid testing, specifically species and gender identification. This information would be confirmatory and can be simultaneously extracted from samples during body fluid analysis.

The major goals of this application are to i) establish body fluid fingerprint assays for menstrual blood and vaginal fluid, ii) identify those protein of greatest value for species identification and make them a routine part of mass spectroscopy body fluid assays, and iii) determine assay conditions for gender identification from blood. Finally, we propose to iv) evaluate the effects of the standard crime scene reagent (Bluestar) on body fluid detection by mass spectroscopy.

The successful completion of this work will not only strengthen the quality of body fluid analyses, but expand testing to include species and gender, likely making mass spectroscopy the standard for body fluid testing against which other methods will be measured.

We believe that this application not only addresses the research and development goals this solicitation (NIJ-2010-2401) which seeks "Identification and/or characterization of biological markers that have the potential to reveal additional or more powerful information about the source of the biological evidence", but also the recommendations of the recent National Academy of Sciences report Strengthening Forensic Science in the United States: A Path Forward which calls for greater research and development in areas forensic science outside of DNA analyses which already has a strong scientific foundation.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K228

The University of Tennessee

"Evaluating the Use of DNA and RNA Degradation for Estimating the Post-Mortem Interval"

Principal Investigator:

Dr. Arpad Vass
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Funding Amount:

$167,414 for 1 year

Abstract:

Although the post-mortem interval (PMI) is important in the investigation of criminal cases, there is no accurate method for estimating post-mortem intervals ranging from weeks to years. This is because decomposition is heavily influenced by factors such as environmental conditions (moisture, temperature, ecosystem, insects, animals and season), the circumstances of the death and the location of the body so that the stage of decomposition of a body is not always a reliable indicator. Despite decomposition studies at the Anthropological Research facility at the University of Tennessee, there is little published research on the degradation of nucleic acids in human cadavers which includes an assessment of the environmental conditions. Improvements in this area have the potential to advance the field of forensic pathology.

The purpose of this proposal is to investigate the decay of nucleic acids in human cadavers as we believe that this may be a useful indicator of the PMI over extended time periods. To do this, we will adapt and develop more robust molecular biology tools and using a candidate marker approach, apply them in a forensic setting with the aim of providing evidence based tools. Our approach is to undertake the systematic measurement of the rate of decay of nucleic acids of both DNA and RNA in human cadavers with known PMI and kept in known conditions.

While DNA has been used for over twenty years in forensic biology the potential applications for RNA have only recently received attention after the revelation that RNA is more stable than previously thought. By studying DNA and RNA from aged and/or degraded samples we expect to learn more about the processes involved in decomposition as they affect nucleic acids and this has the potential to be of benefit in the traditional analysis of such compromised samples.

Human cadavers with known biometric data will be located at the Anthropological Research Facility at the University of Tennessee. A unique aspect of this research is being able to take multiple samples from various human cadaver tissues at different time intervals without interfering in the decomposition process. The body tissues used in this research will be ribs, nails and teeth because these are slower to degrade and are more likely to lead to the PMI indicators we are seeking. A critical aspect of assessing nucleic acid degradation will be the recovery of RNA and DNA without any further fragmentation. We

have previously shown that the DNA IQ™ extraction system can be successfully adapted to allow the co-extraction of RNA and DNA without compromising either. An important practical aspect of this work is the further adaptation of this method to co-extract RNA and DNA from bone and tissue samples such as those described here. This will ease implementation into forensic laboratories as many already have the necessary skills to perform this adapted extraction strategy. After initial research to establish the most useful genetic markers and the experimental system required for analyses then, we will assess whether ribs, nails or teeth are preferred as tissues for PMI estimation in this manner. By assessing the relative rates of decay statistically and establishing whether correlations exist between markers and PMIs, we will aim to have robust analytical tools, backed by sound statistical analysis. This proposal provides an exciting opportunity to capitalize on modern molecular biology techniques with the potential to provide new and powerful statistically based tools that can bring forensic biology and forensic pathology together with the potential to reveal crucial information about the circumstances surrounding a potential crime.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K227

UNT Health Science Center at Fort Worth

"Addressing Quality and Quantity; the Role of DNA Repair and Whole Genome Amplification in Forensically Relevant Samples"

Principal Investigator:

Dr. Bruce Budowle
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Funding Amount:

$363,613 for 2 years

Abstract:

A variety of solutions which address the problems encountered when profiling forensic samples that contain a limited quantity of low quality DNA have been pursued. These include in vitro DNA repair and whole genome amplification (WGA). Neither of these methods has been implemented on an operational scale. Adoption of the methods by casework laboratories may be low due to the perceived risk/benefit ratio for these methods and may present a barrier for their widespread adoption. Available data on the downstream effects of template generation in this manner is not sufficient to warrant effort by the forensic community to invest in the technologies. It is not known how much additional information or success can be gained and the number or type of cases/samples that would be impacted remains undefined. To employ these methods, it is necessary to determine if DNA repair or WGA introduce errors that affect the reliability of DNA typing results. The goal of this proposal is to develop and identify the optimal approach(es) to DNA repair and WGA and determine if they are suitable for use with commonly encountered sources of degraded and low copy DNA.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K139

University of Central Florida

"Molecular Characterization of Trace Biological Evidence for the Optimized Recovery and Analysis of 'Touch DNA'"

Principal Investigator:

Dr. Jack Ballantyne
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Funding Amount:

$304,657 for 2 years

Abstract:

The ability to obtain genetic profiles of the donor of trace biological or touch DNA evidence has been well established, albeit that many such samples comprise mixtures of two or more donors. However, the true nature of touch DNA evidence has remained elusive, generally perceived to be the result of DNA obtained from shed skin cells yet never confirmed with scientific certitude. This is largely due to the perception that it is not possible to ascertain the tissue source of origin of the biological material in touch DNA evidence. The uncertainty with regard to the source of trace biological material is now being exploited in some criminal proceedings in an attempt to diminish the significance of trace biological evidence. Thus far, research has failed to provide operational crime laboratories with feasible methods to identify the tissue source of origin of touch DNA samples. The proposed work seeks to provide a comprehensive characterization of the biological material recovered from touch DNA evidence and, uniquely, provide molecular-based approaches for the positive identification of a skin tissue source of origin. Additionally, standard and enhanced amplification strategies will be used to recover single source STR profiles of the donor(s) of the recovered micro-particles that are the constituents of touch DNA.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K229

University of Tennessee Knoxville

"Developing an Empirically-Based Ranking Order for Bone Sampling: Examining the Differential DNA Yield Rates between Human Skeletal Elements over Increasing Post Mortem Intervals"

Principal Investigator:

Dr. Amy Mundorff
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Funding Amount:

$200,316 for 1 year

Abstract:

This study would be the first to establish a comprehensive ranking of skeletal elements according to each bone's potential to provide usable genetic material for a DNA identification. Current DNA sampling practice is based on the collective wisdom of practitioners. Recent evidence questions the accuracy of this collective wisdom (Mundorff et al. 2009). To date, there has never been a prospective study to evaluate the differential preservation of DNA by skeletal element. This would be the first study to prospectively measure DNA yield rates from each skeletal element. It would replace intuition with empirically based data and provide investigators with a clear DNA sampling strategy.

Unidentified skeletal remains often challenge forensic investigators. Ante mortem records are not always available. This is particularly true during identification projects tied to mass grave excavations, or disaster projects where entire families or communities have been killed. In such cases, the only means of identification may lie in the bones' DNA. Experience teaches that, as remains decompose, skeletal elements including bones and teeth yield higher levels of DNA than muscle. Additionally, skeletal material often survives long after muscle tissue has decomposed. While bone protects DNA better than muscle, all bones are not equal and some yield DNA at higher rates than others.

A recent study by Mundorff et al. (2009) used a subset of remains from the World Trade Center Identification Project to measure differential DNA preservation by skeletal element. Interestingly, they found that bones generally bypassed in DNA sampling yielded DNA at surprisingly high rates. The better yielding bones included several smaller elements. This has tremendous implications for current policy and practice. These researchers point out that small bones, such as the patellae and metatarsals, can be removed easily with a disposable scalpel. On the other hand, midshaft femur, which is typically sampled, is difficult to section, time consuming, and requires a bone saw. Not only are disposable scalpels less labor-intensive, they are also cheaper thanbone saws and do not require electricity or decontamination between sampling (Mundorff et al. 2009). And, by sampling those elements most likely to yield DNA first, agencies can reduce costly and time-consuming retesting.

The proposed research project would develop empirically based bone-sampling standards to maximize the success rate of identifications from bone of varying post mortem intervals. The goal of this project is to analyze the DNA yield rates of different skeletal elements from 3 skeletonized individuals. This will allow us to rank the most successful elements. Next, skeletons from increasing post mortem intervals (the period of time from the individual's death to the present time) will be tested to assess whether the same bones successfully yield sufficient DNA for identification 0-3, 3-10, 10-20, and 20+ years post mortem.

While investigators increasingly rely on DNA to identify remains, DNA tests are expensive and time-consuming. The ability of DNA testing to aid in identification is directly related to the ability to obtain sufficient DNA. Initial sampling of those elements most reliably yielding DNA reduces costly and time-consuming retesting. This project will allow us to determine which skeletal samples are most likely to provide both the quantity and quality of DNA needed to produce DNA profiles from increasing post mortem intervals. This will provide much needed guidance to those who take DNA samples, on which samples are best suited for DNA testing. By determining which skeletal element is most likely to yield a DNA identification, expensive and time consuming retesting can be avoided. It will also speed identifications, which is beneficial to investigators as well as to the decedent's family.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K226

Yale University

"Developing a Forensic Resource/Reference on Genetics Knowledge Base"

Principal Investigator:

Dr. Kenneth Kidd
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Funding Amount:

$643,771 for 2 years

Abstract:

This proposal seeks to make allele frequency data for SNPs and other genetic polymorphisms more accessible and useful in a forensic setting. The primary objective of the project is to provide a web interface 'Forensic Research/Reference On Genetics knowledge base' FROG-kb (prototype at http://frog.med.yale.edu/FrogWeb/) conducive for teaching, research and a referential tool from a forensic standpoint. The underlying data will be provided by the already extensively used and referenced ALlele FREquency Database ALFRED (http://alfred.med.yale.edu). As of March, 2010, ALFRED already contains data on over 650,000 molecularly defined polymorphisms representing data on almost 700 populations for a total of almost 1.5 million allele frequency tables. Many of those are markers used in forensics or published in the forensic literature for possible use. The project would allow even more specifically forensic SNP and STR data and information to be curated and entered. The new web based interface for FROG-kb will be designed to make these data available to forensic students, researchers, and practitioners in a relevant user-friendly manner. Modified versions of search tools already available from ALFRED will be implemented on FROG-kb to make it more suitable for forensic purposes. In addition to displaying data in an organized manner, multiple computational tools that operate utilizing the underlying allele frequency and user provided data will be available from FROG-kb. These tools will be organized by the calculation methodology to be used and the different published SNP/marker panels. Computations will involve both determining the match probability of an input multi-SNP profile using the population data already stored as well as calculations estimating the relative likelihoods of the multi-SNP profile having ancestry from any population in the database. Interfaces for these calculations will be specifically designed for defined panels of SNPs. Functions that can facilitate user defined SNP panels will be available for research and teaching purposes. A FROG-kb

wiki application will be established to encourage forensic expert involvement in the building of the interface and functionality. We expect FROG-kb to be a venue for individuals from different forensic backgrounds to communicate and collaborate.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-DN-BX-K225

Yale University

"Further Development of SNP Panels for Forensics"

Principal Investigator:

Dr. Kenneth Kidd
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Funding Amount:

$1,351,352 for 2 years

Abstract:

We have shown that single nucleotide polymorphisms (SNPs) can provide equivalent discrimination in individual identification to the CODIS markers that are the current gold standard in forensic identification based on DNA. Our panels of Individual Identification SNPs (IISNPs) lack the forensic databases for tracking repeat offenders but are applicable in many circumstances that do not require the offender databases. The panels give probabilities of a random match that are very low (<10-15) and largely independent of ancestry because they were selected to be highly heterozygous around the world. In contrast, selected SNPs can be good for other forensic tasks such as inference of ancestry. The CODIS markers are not good for inference of ancestry precisely because these STR polymorphisms were chosen because they are highly heterozygous everywhere. SNPs, in contrast, can vary greatly around the world and panels can be assembled to specify ancestry of relatively unadmixed individuals to a subcontinental level. We are working on such a panel of Ancestry Informative SNPs (AISNPs) that is already able to provide reasonable probabilities of assignment of an individual to one of nearly a dozen regions of the world. By the time this proposed project will start, we will have increased the distinctions among some of these regions of ancestry. In this application we propose to strengthen those distinctions that are not yet clear and extend the study beyond the current set of 44 populations to a minimum of 57 populations in our lab. In addition, some SNPs are clearly related to certain phenotypic traits such as skin color, eye color, and hair type. We propose to include more of those markers that are potentially phenotype informative SNPs (PISNPs) in the population studies. A fourth type of DNA polymorphism panel is one with high probability of identifying membership in an extended family (a restricted genetic lineage, clan), especially for mass disaster identification. We think that small haplotypes (mini-haps) will be able to serve such a function. A mini-hap will consist of three to five SNPs within a molecular segment small enough (~3 kb) that recombination is exceedingly rare yet the haplotype system has high heterozygosity. We have already identified several such provisional mini-haps documenting the feasibility of such Lineage Informative markers (LISNPs). We propose to focus on development of this last class of SNPs because they can combine at the same time considerable information on ancestry and phenotype. Finally, the existence of a SNP adjacent to one of the CODIS STRpolymorphisms or one of the 26 miniSTR markers of Hill et al. (2008) can establish a SNPSTR, if the phase can be determined, that provides much more information. We will work to identify and determine the global allele frequencies of such SNPs and, if deemed potentially useful in forming a SNPSTR, will test it in combination with the adjacent STRP.

In summary, we are proposing to characterize additional SNPs that can be of value in forensics and provide the global population allele frequency data necessary to support their appropriate use in forensics. We are expanding our SNP characterization from the 44 populations in our previous work to a minimum of 57 populations.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-MU-R-0980

American Registry of Pathology

"Characterization of X Chromosomal Short Tandem Repeat Markers for Forensic Use"

Principal Investigator:

Ms. Toni Diegoli
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Funding Amount:

$83,018 for 1 year

Abstract:

The use of X chromosomal short tandem repeat (STR) markers has been greatly increasing in the forensic setting. The marker system offers the potential to provide information in addition to that obtained from autosomal STR systems currently used at crime laboratories and the courtroom, and in certain scenarios, markers on the X chromosome may be the only means of obtaining this information. Any investigated relationship situation where at least one female is involved will benefit from the use of X chromosomal STRs, which can be applied to cases of missing persons, criminal incest, immigration, deficiency paternity or other questioned relationships. In-depth characterization of the marker system is the first step in maximizing the power of this additional tool in the forensic arsenal.

In previous work performed at the Armed Forces DNA Identification Laboratory (AFDIL), two mini-X chromosomal STR multiplexes capable of amplifying 15 total markers were developed. These assays use techniques and instrumentation that is already in use in most laboratories for autosomal STR analysis. Developmental validation of the system was completed and allele frequencies have been recorded in a number of population groups. Therefore, a tool with which to further characterize this marker system already exists.

The 1991 report of the International Society for Forensic Genetics (ISFG) relating to the use of DNA polymorphisms in paternity testing has been used as a guideline for the evaluation of other marker systems such as autosomal STRs. Several requirements of this report remain unresolved for X chromosomal STRs. First, mutation rates must be known in order to adequately handle possible mismatches attributable to mutational events. Second, questions of independent assortment and linkage disequilibrium must be addressed. Both of these issues will be investigated in this proposal through the study of relevant family groups and populations. Additional population data generated as a result of these studies will also be reported, and will contribute to the continuing characterization of these markers.

Lastly, mixture interpretation is an important part of the forensic scientist's role in evaluating evidence from a crime scene, where mixed stains are common. This proposal seeks to use X chromosomal STRs to aid in the interpretation of such mixtures, providing clues as to the number of contributors to a sample

and the gender of those contributors. To this end, a mixture multiplex has been created that combines markers from both the X and the Y chromosomes in an attempt to maximize the information gained from these mixtures and potentially influence the direction of further testing. Extensive testing of this mixture multiplex with a variety of known mixtures and, eventually, mock casework samples is proposed.

In conclusion, the goal of this proposal is to perform mutation rate studies, linkage analysis, and mixture evaluation in order to further characterize the X chromosomal STR marker system for forensic use.

NIJ Point-of-Contact

Program Manager: Minh Nguyen

2010-MU-R-0980

American Registry of Pathology

"Maximizing mtDNA Testing Potential with the Generation of High-Quality of mtGenome Reference Data"

Principal Investigator:

Dr. Jodi Irwin
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Funding Amount:

$1,860,808 for 3 years

Abstract:

Mitochondrial DNA (mtDNA) testing in the forensic context requires appropriate, high quality population databases for estimating the rarity of questioned haplotypes. If the mtDNA haplotypes of the evidence and the reference are consistent, the frequency of the haplotype, as determined from an appropriate reference population database, provides an estimate of the likelihood that the evidence profile is maternally related to the reference rather than a random individual in the population. Since 2003, and primarily with funding provided by the National Institute of Justice, the Armed Forces DNA Identification Laboratory has been systematically generating mtDNA control region data to augment available reference population data and ultimately to improve the framework upon which forensic mtDNA typing is based. Over 20,000 haplotypes have been generated since 2003, and nearly one-fourth of those sequences are now publicly available for use in statistical interpretation of mtDNA control region evidence.

Nevertheless, it is the case that these data, and indeed all available forensic mtDNA reference databases (SWGDAM, EMPOP), only include information from the mtDNA control region. While this information is obviously strengthening the foundation upon which current mtDNA identification efforts are based, these data do not adequately prepare the field for the recent and rapid advancements in mtDNA typing technologies. Novel assays that quickly and easily access

mtDNA coding region data for increased discrimination are now available (and in many cases their development has been funded by the National Institute of Justice) in the form of single nucleotide polymorphism (SNP) assays, sequence specific oligonucleotide (SSO) strips, mass spectrometry instrumentation and next generation sequencing (NGS) technologies. The massively-parallel sequencing enabled by NGS technology is revolutionizing genetic data generation and, in the not-too-distant future, is likely to make the development of entire mtDNA genome profiles from even highly degraded specimens relatively straight-forward and cost effective.

However, particularly in the case of mtDNA, the genetic evidence is only as powerful as the reference population data available for comparison. Currently, there is a dearth of appropriate, randomly-sampled

and high-quality entire mtGenome reference data suitable for forensic comparisons. Thus, in the near future, it seems that the application of mtDNA coding region data in routine forensic casework will be dictated less by the quantity of specimen and/or effort required to produce the data than by the availability of large high-quality entire mtGenome population databases that can be used to determine the rarity of mtGenome haplotypes. Until these databases are available, the utility of novel mtDNA typing technologies that lead to greater success in recovering highly discriminatory data from the most compromised forensic specimens will be limited.

In this proposal, we seek an expansion of control region mtDNA databasing efforts to 1) increase the large-scale availability of entire mtDNA genome reference population data and 2) improve the information technology infrastructure required to access mtGenome data and employ them in forensic applications. With the large-scale availability of high quality entire mtGenome data, forensic mtDNA interpretation guidelines can be greatly improved and the full potential of mtDNA testing in forensic casework can be realized.

NIJ Point-of-Contact

Program Manager: Minh Nguyen