Forensics@NIST 2012 Symposium
Abstracts by Day/Discipline

November 28, 2012 – Day One

Forensic Biology/DNA, Firearms Analysis, and Fire Research Sessions – Green Auditorium

DNA Stability, Extractions and Quantitation

9:05-9:25 Stability Studies for DNA in Bloodstains and as Extracted Material

Author:
Margaret C. Kline, MS, Applied Genetics Group, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8314

Attendees will learn about the National Institute of Standards and Technology (NIST)'s ongoing DNA stability studies.

Many reference DNA sample repositories or "DNA banks" are now in existence to enable identification of forensic evidence or human remains as well as support epidemiological and genetic research and diagnosis. No DNA bank can satisfy its intended goals unless the desired genetic information latent in the original sample can be accessed analytically. NIST has studied the stability and accessibility of DNA in bloodstains and in extracts for over 20 years. The materials, methods, and technologies used by the forensic human identity and clinical communities have changed radically during this period.

Initial studies focused on availability of DNA from dried bloodstains on the then-usual 903 cotton filter paper matrix stored at liquid nitrogen, -80 °C, -20 °C, and ambient temperatures. These studies were expanded to include the then newly-developed FTA coated paper matrix and storage at + 37 °C. Studies on the stability of DNA extracts stored in buffered aqueous solutions (TE buffer) supported the development of a series of Standard Reference Materials® produced for the forensic DNA community as well as the evaluation of new materials designed to assist in the storage of extracted DNA at ambient temperature. Likewise, the effects of shipping on DNA samples of various forms packaged in several ways have been studied; most recently an investigation of the effects of exposure to ionizing irradiation as used in package screening.

DNA stability has been assessed using the highly multiplexed Short Tandem Repeat (STR) DNA typing technologies used by the human forensic identity community. The current stability metric is obtaining a complete "STR profile" using the several 16-plex commercial typing kits now available. Full STR profiles have been obtained for DNA from dried bloodstains stored at ambient temperature for 11 years on both 903 and FTA paper matrices and for stains stored on the FTA matrix at +37 °C for 11 years. Samples stored on the 903 matrix at +37 °C for 11 years

were appreciably degraded but only one STR locus could not be typed using a commercial kit; however, full profiles for these samples were obtained using the newer "miniSTR" kits developed from other work performed at NIST.

DNA extracted into TE buffer is a convenient and safe way of delivering reference materials to the forensic community using commercial shipping. To be useful, however, the packaging used to contain the DNA must not change the DNA and the recipient of the shipment must be able to conveniently make use of the shipped material. Numerous "tubes" have been evaluated, several that significantly bind extracted DNA to the tube walls. In the absence of high-dose radiation, PFA-based tubes are best but highly polished HDPE tubes may be superior when shipping involves high-dose X-ray irradiation.

Synthetic DNA stabilizer materials designed to allow the storage of extracted DNA at ambient temperature in a dried state have been tested with extracted DNA stored in tubes/plates and on paper matrices. Preliminary data from these studies indicate the use of such material was not detrimental and in some cases may be advantageous.

Keywords: DNA stability, Short Tandem Repeat, Bloodstain stability

Author Bio:
Margaret C. Kline is a Research Biologist with the Applied Genetics Group at NIST. Her work at NIST has focused on the development and production of Standard Reference Materials® for the forensic DNA community and the clinical community, as well as conducting interlaboratory studies to help determine the "state of the art" of analytical techniques involving human identity projects including STR Kit evaluations, DNA quantitation issues, and mixture interpretation issues.

9:25- 9:40 DNA Extraction Efficiency: Is it what you thought?

Authors:

Erica L.R. Butts, MFS, Applied Genetics Group, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8314

Title

DNA Extraction Efficiency: Is it what you thought?

Learning Objective

After attending this presentation, attendees will understand the importance of evaluating extraction efficiency from an original and known amount of DNA. Attendees will also learn that the observed recovery value range was significantly lower (20-30%) than many reported extraction efficiency calculations using the number full STR profiles produced.

Impact Statement

This presentation will impact the forensic community and/or humanity by bringing attention to the amount of DNA unrecovered during the extraction process. The evaluation of the amount of unrecovered DNA could lead to more efficient methods to recover higher percentages of DNA from the extraction and purification processes.

Abstract

Forensic DNA typing requires a specific quantity of input DNA (typically 0.5 - 1.0 nanograms) to generate an optimal short tandem repeat (STR) profile. For reference samples, the amount of DNA collected on a standard buccal swab or blood punch is generally in excess of that which is needed for testing (on the order of hundreds of nanograms (ng)). Typically, extraction efficiency is evaluated by determining the number of samples that produce a full STR profile divided by the total number of samples processed. Less attention has been paid to the amount of DNA unrecovered during the extraction process. The importance of evaluating the theoretical yield versus the functional yield is in cases when the amount of available DNA is low. In these cases it would be beneficial to obtain an extraction recovery that is closer to the theoretical yield than the functional yield. Evaluating the amount of unrecovered DNA could lead to more efficient methods to recover higher percentages of DNA from the extraction and purification processes. Extraction efficiency experiments were conducted to evaluate the percentage of DNA recovered through two extraction methods: a salting out procedure [1] and use of the Qiagen EZ1 Advanced XL Extraction robot. Several DNA sources were tested in duplicate using different concentrations of human epithelial cells, previously purified DNA, or liquid whole blood. Controlled amounts of DNA from epithelial cells were absorbed onto cotton buccal swabs, Whatman 903 paper and in a liquid Phosphate Buffered Saline (PBS) suspension. Protocols were adjusted to evaluate incubation time length as a variable for extraction recovery. Theoretical DNA quantities were calculated for total nanograms of DNA and applied to estimate a recovery percentage for each extraction. The DNA contained in whole blood concentrations ranged from 24 ng to 4800 ng, while previously extracted DNA concentrations examined ranged from 100 ng to 1500 ng. Human epithelial cells were quantitated using a Coulter Counter and diluted with PBS to appropriate concentrations (300 ng, 600 ng, 1200 ng). Extracted samples were quantified with the use of a modification of the Centre of Forensic Sciences TH01 quantitive PCR assay [2]. Results indicated that the amount of DNA recovered from either extraction method and all DNA sources ranged from 20 - 30% of the initial amount of input DNA. The observed recovery value range was significantly lower than many reported extraction efficiency calculations using the number of full STR profiles produced. References: 1. S.A. Miller, D.D. Dykes, H.F. Polesky, A simple salting out procedure for extracting DNA from human nucleated cells, Nucl. Acids Res. 16 (1988) 1215. 2. Richard, M.L., Frappier, R.H. and Newman, J.C. (2003) Developmental validation of a real-time quantitative PCR assay for automated quantification of human DNA. J Forensic Sci, 48 (5): 1041-1046

Keywords

Extraction, efficiency, recovery

Author Bio

Ms. Erica Butts received her Bachelor of Science at Valparaiso University in Biology in 2006 and then received her Master of Forensic Science at George Washington University in Forensic Molecular Biology in 2008. Upon graduation from GWU, she worked for Fairfax Identity Laboratory in Richmond, VA specializing in immigration and legal paternity cases as well as CODIS data-banking. Erica has be`en working as part of the Biometrics and Human Identity Group since August 2009.

9:40 – 10:00 Rapid High Sensitivity DNA Extraction Using Direct Rapid Analysis Generating Extracted Nucleotides (DRAGEN)

Authors:

David Ross*, NIST Alyssa Henry, Applied Research Associates Elizabeth Strychalski, NIST Chris Konek, Applied Research Associates

Title

Rapid High Sensitivity DNA Extraction Using DRAGEN (direct rapid analysis generating extracted nucleotides)

Learning Objective

This presentation will describe work to develop a new technique for DNA extraction and purification.

Impact Statement

The presentation will educate the forensic community regarding new technologies being developed for forensic DNA analysis

Abstract

This presentation will describe work to develop a new technique for DNA extraction and purification. The technique, termed DRAGEN (direct rapid analysis generating extracted nucleotides), is qualitatively different from conventional DNA extraction techniques in that it uses electric fields to pull the charged DNA molecules out of a sample solution rather than solid-phase capture. Proof-of-concept experiments have shown that the technique can extract and deliver sufficient DNA for STR profiling (1-2 ng) from crude samples containing soil and PCR inhibitors such as humic acid. The technique is fast (5 minutes); it works with particulate- and inhibitor-laden samples with minimal sample pre-preparation; it delivers purified DNA into a small volume (5 10 μL) ready for PCR amplification; and it requires simple hardware, making it a promising new technology for stand-alone DNA extraction and for integration into complete DNA analysis systems. The presentation will also discuss the optimization of the technique to improve the extraction efficiency so that it can be used with dilute or 'low template' DNA samples such as diluted blood and swabs from water bottles or cell phones.

Keywords

DNA extraction,

Author Bio

David Ross has been at NIST for 13 years. He has a PhD in Physics and a background in the development of microfluidic technologies.

10:00 – 10:20 Digital PCR & DNA Quantitation

Authors:

Ross Haynes* NIST 100 Bureau Drive, Gaithersburg MD 20899

Title

Principles of Digital PCR

Learning Objective

A better understanding of the underlying principles of digital PCR and potential measurement issues will allow scientists to make informed decisions on how to employ this technology in their research as well as in the lab.

Impact Statement

Digital PCR is a new technology that is anticipated to be widely used in the future. An understanding of this technology, the potential measurement issues, and platform types will allow labs to make informed decisions about employing digital PCR.

Abstract

Quantitation of DNA is important in forensic sciences. Digital PCR (dPCR) is a PCR based method that allows for absolute quantitation of DNA without the use of a calibrant DNA. Digital PCR is being used at NIST to certify Standard Reference Materials (SRMs) for concentration in copies per microliter. The presentation will go over how digital PCR works, a comparison between dPCR and qPCR, an intuitive look at Poisson statistics, possible measurement issues, and platform types.

Keywords

digital PCR quant

Author Bio

Ross Haynes started at NIST in 2005, working on Consultative Committee for Amount of Substance (CCQM) Key Comparison 61 (K61), which looked into aspects of commutability in qPCR. In 2008 he started working on DNA-based clinical reference materials. SRM 2366 Cytomegalovirus for DNA Measurements was put out late 2011 and is certified for copies per microliter by digital PCR.

STRs, mtDNA, Rapid DNA

10:50 – 11:10 Commercial STR Multiplex Kit Testing at NIST and the Value of Additional Loci

Authors:

Carolyn R. Hill, MS, Applied Genetics Group, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8314

Title

Commercial STR Multiplex Kit Testing at NIST and the Value of Additional Loci

Learning Objective

Attendees will understand the value of concordance testing using commercial forensic DNA short tandem repeat (STR) multiplex kits to detect allelic dropout or "null" alleles present in a standard data set as well as the importance of additional autosomal STR loci for use with the US national database.

Impact Statement

This presentation will impact the forensic community by demonstrating that null alleles do occur within a standard data set when comparing STR multiplex kits with different primer sequences. These null alleles have been sequenced to confirm the results and determine the cause (primer binding site mutations) and are reported to the forensic community.

Abstract

Concordance evaluations are important to detect allelic dropout or "null alleles" present in a data set and are performed because there are a variety of commercial STR multiplex kits with different configurations of STR markers. When multiple primer sets are used, there is concern that allele dropout may occur due to primer binding site mutations that affect one set of primers but not another and these null alleles become evident only when data sets are compared. Multiple concordance studies have been performed at NIST with a standard sample set (~1450 in-house U.S. population samples) using various STR multiplex kits from Applied Biosystems, Promega, and Qiagen. The Federal Bureau of Investigation (FBI) recently announced the expansion of additional core loci for use in the US national database, including recently adopted European STR markers, to provide greater capabilities for international comparisons as well as concern over potential adventitious matches between DNA profiles when trillions of comparisons are being performed with DNA database searches involving millions of profiles. A summary of the results, including discordance and kit performance results, will be presented in order to help assess the benefits of performing concordance testing using a standard data set with STR multiplex kits that have different primer sequences for the same markers, as well as results from additional STR loci that are required for the expansion of the core loci for use with the US national database.

Keywords

DNA, concordance, multiplex

Author Bio

Becky Hill received her bachelor of arts at The University of Virginia in Biology and then received her master of science at George Mason University in Molecular Biology. Upon graduation from UVA, she worked for the American Red Cross for two years doing research for the Plasma Derivatives division. She then went on to work for a small biotech company called Clearant for 5 years doing research with blood proteins. After receiving her masters at GMU, she began working for the Human Identity Project Team at NIST. She has been working in this group for 7 years.

11:10-11:30 Forensic DNA Information Resources and Training

Authors:

John M. Butler, PhD, Applied Genetics Group, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8314

Title

Forensic DNA Information Resources and Training

Learning Objective

Attendees will understand NIST information resources regarding forensic DNA and training conducted in recent years.

Impact Statement

The forensic community and society have benefited from DNA technology. Our group at NIST enables forensic DNA testing by bringing technology and traceability to the scales of justice.

Abstract

The Applied Genetics Group at NIST has been funded for the past two decades by the National Institute of Justice through an interagency agreement with the NIST Office of Law Enforcement Standards. We have a three-part focus: (1) creation of reference materials to enable calibration of forensic DNA measurements, (2) development and evaluation of technologies to improve DNA analysis, and (3) enabling the community to better use DNA technology through training scientists, lawyers, and members of the general public. Information resources developed by our NIST team are shared through (1) training workshops conducted at scientific conferences or in forensic laboratories, (2) the "Forensic DNA Typing" textbooks (four volumes have been published so far), (3) published research papers and book chapters, and (4) on-line via a widely-used website known as STRBase (http://www.cstl.nist.gov/biotech/strbase/). This presentation will briefly review the content of STRBase, the "Forensic DNA Typing" textbooks, and some of our training workshops. The process for developing training materials will be discussed along with their impact on improving the forensic DNA community.

Keywords

DNA, STRBase, training

Author Bio

John M. Butler is a NIST Fellow and Leader of the Applied Genetics Group at NIST. He did his PhD research at the FBI Laboratory developing DNA analysis methods for short tandem repeat (STR) markers using capillary electrophoresis. Dr. Butler is a member of the American Academy of Forensic Sciences and the International Society of Forensic Genetics. He has authored four textbooks on Forensic DNA Typing and over 130 peer-reviewed articles and invited book chapters. In July 2011, Dr. Butler was named by ScienceWatch.com as the #1 world-wide high-impact author in forensic science over the past decade.

11:30 – 11:50 Exploring the Capabilities of DNA Mixture Interpretation Using a Probabilistic Genotype Approach

Authors:

Michael D. Coble, PhD Applied Genetics Group, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8314

Title

Exploring the Capabilities of DNA Mixture Interpretation Using a Probabilistic Genotype Approach

Learning Objective

Attendees will understand recent NIST efforts to explore a probabilistic approach to the interpretation of challenging DNA mixtures.

Impact Statement

This presentation will impact the forensic community and/or humanity by highlighting the improvements in information gained from probabilistic approaches to DNA mixture interpretation compared to current "threshold assessments" of mixture data used in crime laboratories.

Abstract

DNA mixture interpretation of evidence from sexual assaults or high volume crimes such as burglaries – especially when the stain is degraded or compromised – can be challenging for the forensic scientist to decipher. In the US, the Scientific Working Group on DNA Analysis Methods (SWGDAM) released their revised STR Interpretation Guidelines to provide the forensic DNA community with principles and guidance for mixture interpretation. Methods to move beyond the present use of thresholds (such as an interpretation or stochastic threshold) to include probabilistic modeling of mixtures will be discussed using a commercially available software program that utilizes a Bayesian evaluation of the mixture data via Markov Chain Monte Carlo (MCMC) modeling of the data to determine the most probable genotypes present.

Keywords

Mixtures, Interpretation, Genotypes

Author Bio

Dr. Michael Coble is a Forensic Biologist in the Applied Genetics Group at NIST. He received his B.S. degree in Biology from Appalachian State University, his Master's Degree in Forensic Science and his Ph.D. in Genetics from the George Washington University. In 2009, Dr. Coble received the Washington Academy of Sciences Award for work of merit and distinction in the Biological Sciences. He was recently listed among the top 20 high-impact authors in Legal Medicine and Forensic Science from 2001-2011 by ScienceWatch.com. His current research at NIST focuses on DNA mixture interpretation and research with haploid markers.

11:50 – 12:10 Alternative Methods for Human Identification: Base Composition Profiling by Electrospray Ionization Time-of-Flight Mass Spectrometry

Authors:

Kevin M. Kiesler, M.S.*, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899

Title

Alternative Methods for Human Identification: Base Composition Profiling by Electrospray Ionization Time-of-Flight Mass Spectrometry

Learning Objective

This presentation will introduce the concepts and methodology of DNA analysis by electrospray ionization time-of-flight mass spectrometry.

Impact Statement

The research findings presented herein are intended to guide forensic practitioners in the practical aspects of adopting mass spectrometry as a technique for use in human identification by DNA analysis.

Abstract

Mass spectrometry base composition profiling represents an advance in the technology for forensic identification of biological material. The technique represents an improvement over the current method of DNA sequencing through reductions in cost, labor, and time required to generate a result. This presentation will describe the methods and applications of mass spectrometry of DNA for forensic human identification. Several assays are commercially available for analysis of DNA markers using the Plex-ID ESI-TOF mass spectrometer. The format and content of assays for Mitochondrial DNA, SNPs, CODIS STRs, and Y-STRs will be presented. Experiments have been performed at NIST to determine the limits of detection and concordance rate of the Mitochondrial DNA assay. The mtDNA 2.0 assay is capable of producing full profiles of 24 amplicons at DNA inputs well below the manufacturer's suggested minimum PCR template quantity of 200 pg per sample, divided into eight triplex PCR reactions. Concordance rates with standard DNA sequencing protocols were within acceptable tolerances. Significant savings in cost and labor inputs, combined with high levels of sensitivity make the ESI-TOF mass spectrometry technique well suited to the forensic human identification laboratory. A wide range of assays allows for flexibility in the analysis of different types of samples.

Keywords

Time-of-Flight Mass Spectrometry

Author Bio

Kevin holds a bachelor's degree in Biochemistry and a Professional Science Master's degree in Applied Biosciences, both from the University of Arizona. In his career, Kevin has held positions in molecular biology research and development in an academic biochemistry research lab, the University of Arizona Genomics Core facility, as well as two privately held companies, GMS Biotech, and OpGen, Inc. Kevin's current position as a Research Biologist in the Applied Genetics Group at NIST focuses on assessment of molecular biological methods for human biometrics.

12:10 – 12:30 Rapid Forensic DNA Typing: Protocols and Instrumentation

Authors:

Peter M. Vallone, PhD

Title

Rapid Forensic DNA Typing: Protocols and Instrumentation

Learning Objective

After attending this presentation, attendees will understand the principles of rapid PCR amplification of STR loci, the basics of integrated rapid DNA typing, and applications of rapid DNA typing within the forensic community.

Impact Statement

This presentation will impact the forensic community by detailing the protocols used for rapid PCR amplification and how these methods can be implemented into commercial integrated forensic DNA typing devices. One component of such an integrated platform involves the reduction in time required for multiplex PCR amplification. The potential of reducing the required PCR amplification time may also benefit laboratories typing single-source reference samples.

Abstract

Today's commercial multiplex short tandem repeat (STR) typing kits are not optimized or intended for rapid PCR thermal cycling. Current protocols require approximately 3 hours for amplifying a multiplex containing 15 STR loci plus amelogenin. With the continuing development of miniaturization technologies such as microfluidic and micro-capillary devices, there is a growing interest in developing an integrated DNA typing system capable of going from a buccal swab to a DNA profile in less than 2 hours. Results are obtained in less than 36 minutes when run in a standard peltier thermal cycler employing a heating rate of 4oC/s. Capillary electrophoresis characterization of the PCR products indicates good peak balance between loci, strong signal intensity and minor adenylation artifacts. Genotyping results are concordant with amplification conditions utilizing standard thermal cycling procedures. Assay conditions are robust enough to routinely amplify 750 pg of template DNA. An ongoing evaluation of forensic DNA typing as a potential biometric tool further work with various 'non-standard' thermal cyclers in combination with fast polymerases has resulted in decreasing the PCR amplification time to less than 20 minutes for a 16 locus commercial STR typing kit. The author will present protocols and results from rapid DNA amplifications of common commercial STR kits. A discussion of the application of integrated rapid DNA platforms will be presented.

Keywords

PCR, DNA, STR

Author Bio

Peter M. Vallone received his Ph.D. in Chemistry from the University of Illinois at Chicago in 1999 and was awarded a NRC postdoctoral fellowship that brought him to NIST. After completing his postdoctoral work in 2001 Dr. Vallone became a permanent staff scientist at NIST. Dr. Vallone has worked in the Biochemical Science Division developing multiplex assays

for the detection of genetic variation. Dr. Vallone has developed various software tools for the design of nucleic acid based assays. Dr. Vallone has published over 30 peer-reviewed articles and leads of the DNA Biometrics project team at NIST.

Firearms Analysis: Measurement of Identification for Firearms and Toolmark Evidence

2:00 – 2:20 Establishing the "National Ballistics Evidence Search Engine (NBESE)" Based on 3D Topography Measurements on Correlation Cells - Half-year Report for the NIST 2012 FMC Project

Authors:

J. Song, T.V. Vorburger, R. Thompson, J. Soons, W. Chu, J. Yen, T.B. Renegar, A. Zheng, M. Tong, R. Silver, National Institute of Standards and Technology (NIST)

Learning Objectives

Forensic Firearms and Toolmarks Identification

Impact Statement

This project aims to establish a "National Ballistics Evidence Search Engine (NBESE)" based on the NIST Provisional Patent entitled "An Automated Ballistics Identification System Using 3D Topography Measurements on Correlation Cells" (Application No. 61610029, submitted on March 13, 2012). The proposed NIST Ballistics Identification System (NBIS) and the NBESE can facilitate accurate ballistics identifications and fast evidence searches. The proposed "Congruent Matching Cells (CMC)" can provide a universal identification criterion for ballistics identifications. An error rate reporting procedure can be developed that can greatly add to the scientific support for the firearm and toolmark identifications.

Abstract

The project entitled "Establish the National Ballistics Evidence Search Engine (NBESE) Based on 3D Topography Measurements on Correlation Cells" was awarded with the NIST Forensic Measurement Challenges Program (FMC2012). From May to November 2012, the project team have 1) Proposed "Correlation Cells" and "Congruent Matching Cells" (CMC) method for fast and accurate ballistics identifications and evidence searches; 2) Completed the design for the proposed NBESE; 3) Completed the correlation program for NBESE; 4) Completed initial tests with excellent correlation results; 5) Drafted an error rate report procedure for ballistics identifications; 6) Investigated topography measurement instruments to be used for the NBESE; 7) Completed two journal papers, submitted a provisional patent and conducted four invited talks and conference presentations at US and international conferences.

Key Words

Forensic, ballistics identification, correlation cell

Authors Bio

J. Song is a Project Leader of Forensic Topography and Surface Metrology, PML/SDMD at NIST;
T.V. Vorburger is a Guest Researcher, PML/SDMD at NIST;
R. Thompson is a Program Manager, OLES at NIST;
W. Chu is a Guest Researcher, PML/SDMD at NIST;
J. Soons is a Project Leader, PML/SDMD at NIST;
J. Yen is a Statistician, ITL/SED at NIST;
T.B. Renegar is a Physical Technician PML/SDMD at NIST;
A. Zheng is a Mechanical Engineer, PML/SDMD at NIST;
R. Silver is a Group Leader, PML/SDMD at NIST.

2:20 – 2:40 Initial Tests and Analysis of the NIST Proposed Congruent Matching Cells (CMC) Method using Fired Cartridge Cases from Consecutively Manufactured Pistol Slides

Authors:

Wei Chu, Johannes Soons, Mingsi Tong and John Song National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA

Title

Initial Tests and Analysis of the NIST Proposed Congruent Matching Cells (CMC) Method using Fired Cartridge Cases from Consecutively Manufactured Pistol Slides

Learning Objective

In a test designed to produce the highest probability of false identification of bullet comparison identification, the results from both comparison microscopy and surface profile comparison show very high accuracy results.

Impact Statement

The study extends the empirical research in the determination of a numerical objective criteria of striated toolmarks on fired bullets.

Abstract

In order to test the Congruent Matching Cells (CMC) method proposed by NIST for the project entitled "Establish the National Ballistics Evidence Search Engine (NBESE) Based on 3D Topography Measurements on Correlation Cells", 40 fired cartridge cases from 10 consecutively manufactured pistol slides are examined and analyzed. A total of 780 correlations including 63 matching and 717 nonmatching correlations are implemented. Each single breech face image is divided into small cells for correlation. The test results show that the numbers of matching cell pairs for the topographies obtained from matching breech faces are

distributed in a range of 9-29, while the numbers of matching cell pairs for all 717 nonmatching topography correlations are no more than 3. The proposed CMC method suggests that an empirical Identification Criterion of at least 6 matching cell pairs be used for separating the matching and non-matching topographies. With this criterion there are no false positive or false negative identifications using the NIST proposed CMC method for ballistics identification for this set of cartridge cases. This is the highest identification accuracy for this same set of cartridge cases that we have tested thus far.

Keywords

identification, CMS, stria,

Author Bio

W. Chu is a Guest Researcher at NIST and a Research Engineer at IAI since 10/2010. J. Song, Project Leader, Mechanical Metrology Division (MMD) of NIST.

2:40 – 3:00 2D/3D Topography Comparisons of 10 Consecutively Manufactured Chisels and Punches Through The Cross Correlation Function

Authors:

Alan Zheng John Villanova Robert M. Thompson Thomas Brian Renegar James Yen, PhD Theodore Vorburger, PhD Address for all authors/co-authors: NIST, 100 Bureau Drive STOP 8212, Gaithersburg, MD 20899

Title

2D/3D Topography Comparisons of 10 Consecutively Manufactured Chisels and Punches Through The Cross Correlation Function

Learning Objective

After attending this presentation, attendees will understand that 10 consecutively manufactured chisels and punches all have individual surface topographies that can be used to separate them. They will also learn how to compare the surface topographies quantitatively through the cross correlation function.

Impact Statement

This presentation will impact the forensic community and/or humanity by providing statistical evidence that even though a set of tools are consecutively manufactured, they each have individual marks that can be used to identify them. This study provides scientific validation for toolmark examiners trying to visually tie an evidence toolmark to the tool.

Abstract

In the world of toolmark identification, the most difficult scenario involves consecutively manufactured tools. These have the highest chance of having similar surface topographies which have the greatest chance of possible erroneous identifications. There have been many consecutively manufactured studies using comparison microscopy and experienced firearm and toolmark examiners. These studies relied heavily on empirical data and training which lacks quantitative objective results. The aim of this study is to use the Cross Correlation Function to establish a quantitative value for identification. Ten consecutively manufactured chisels and

punches were obtained from Western Forge (a supplier of craftsman tools) during witnessed manufacturing. Each tool is used to make known matching and known non-matching toolmark comparisons. All of the known matches and known non-matches were correlated against each other using the Cross Correlation Function to establish a statistical distribution for the match and non-match comparison results. These two distributions are then used to establish a minimum CCF score control limit for a matching or non-matching identification. Each tool's identities are then coded and used to make unknown marks. These unknown marks were correlated against all of the known and unknown marks to establish which tool caused the marks. This study provides a mathematical/statistical validation of the empirical methods utilized by toolmark examiners for decades. It will also help them in court when the validity of their science requires support.

Keywords

Toolmarks, Striations, CCF

Author Bio

Alan Zheng is a Mechanical Engineer with the Surface & Nanostructure Metrology Group in the National Institute of Standards and Technology (NIST). He has a B.S. in Mechanical Engineering from University of Maryland Baltimore County as well as a M.S. in Mechanical Engineering from Johns Hopkins University. He has been with the group since 2003 and has worked on many forensic projects related to 3D topography acquisitions and correlations of ballistics evidence. He also has extensive experience in both contact (stylus) and non-contact (optical) surface metrology.

3:00 – 3:20 NIST Bullet SRM 2460 Replication and Validation Using an Improved Vacuum Casting Method and Potential Evidentiary Use

Authors:

Thomas Brian Renegar Robert M. Thompson Alan Zheng John Song James Yen, PhD Theodore Vorburger, PhD Address for all authors/co-authors: NIST, 100 Bureau Drive STOP 8212, Gaithersburg, MD 20899

Title

NIST Bullet SRM 2460 Replication and Validation Using an Improved Vacuum Casting Method and Potential Evidentiary Use

Learning Objective

After attending this presentation, attendees will understand the procedures to replicate any bullet or casing by using the vacuum casting technique. They will also understand the advantages of having a replica bullet or casing to share with their peers instead of using the actual evidence itself.

Impact Statement

This presentation will impact the forensic community and/or humanity by allowing crime labs to replicate case evidence to share with their peers. This eliminates errors in chain of custody as well as allow other examiners to check the identification without having the actual evidence bullet or casing. This work will also allow the standardization of proficiency test samples.

Abstract

In 2011 the Office of Law Enforcement Standards (OLES) at NIST entered into a technology

transfer agreement with the German Bundeskriminalamt (BKA) whereby NIST could use their current polymer replication method to produce the next generation of NIST Standard Bullets (SRM 2460). Within a few months the NIST Project Team had adapted the process using polymer materials more easily obtained in the United States. The replica bullet surface profiles were measured using the same exacting methods used to qualify the Bullet SRMs. Results of those comparisons reveal that the cast replicas are virtually identical to the original SRM bullet that was cast. Another casting procedure is being developed for cartridge cases, bullets, and toolmarks that will be more "crime lab friendly" in materials and hardware. In this way crime laboratories may have the option to make replicas of evidence using a tested and accurate process. These replicas could be shipped to other agencies for analysis without the risk of losing the original evidence. Additionally, proficiency/training sets can be produced that are identical in quality to the original items. The European Network of Forensic Science Institutes Expert Working Group on Firearms and GSR (ENFSI EWG FA/GSR) has sponsored proficiency tests using the vacuum casting method with great success.

Keywords

Vacuum, Replication, Bullets/Casings

Author Bio

Thomas Brian Renegar is a Physical Science Technician with the Surface & Nanostructure Metrology Group in the National Institute of Standards and Technology (NIST). He has been with the group since 1991 and has extensive experience in both contact (stylus) and non-contact (optical) surface metrology. He is currently serving as the vice chair of the ASME B46 committee on the Classification and Designation of Surface Qualities.

Firearms Analysis: Improving Accuracy and Quality Assurance

3:40 – 4:00 Standard Reference Material® 2461 Standard Cartridge Case

Authors: T.V. Vorburger, W. Chu, A. Zheng, T. B. Renegar, J. Yen, J.F. Song, J. Villanova, L. Ma, R.M. Thompson, National Institute of Standards and Technology, Gaithersburg, MD and M. Ols, Bureau of Alcohol, Tobacco, Firearms, and Explosives(ATF), Ammendale, MD

Learning Objectives: To describe the physical properties of the SRM and how it may be acquired and to outline the procedure for using the SRM to test optical identification systems

Impact Statement: SRM 2461 will help crime laboratories 1) to verify that automated optical equipment for cartridge case image acquisition and correlation is operating properly, 2) to establish ballistics measurement traceability and 3)
to achieve accreditation

Standard Reference Material (SRM) 2461 is a physical standard that provides markings of a fired cartridge case. Each unit of SRM 2461 consists of a circular electroformed nickel plate, replicated from the head of a fired master cartridge case, which contains the surface topography signatures of a breech face impression, a firing pin impression, and an ejector mark. The electroformed plate is cemented to a brass cylinder holder so that the assembly resembles a real fired cartridge case. The master cartridge case was fired at the National Laboratory Center of the

ATF. The SRM cartridge cases produced from that master by electroforming have virtually the same surface topography signatures.

SRM 2461 complements the SRM 2460 Standard Bullet developed previously. Each unit of the SRM may be used in two principal ways: first, to test the *Heritage Model of Integrated Ballistics Identification Systems (IBIS) used in crime labs and second, to test systems that directly perform topographic imaging of cartridge cases.

IBIS Heritage systems acquire images of cartridge case surfaces and estimate the similarity of the acquired images using special software. Acquisitions of SRM 2461 obtained by one of the many systems of the National Integrated Ballistics Information Network may be compared with "Golden Images" of the SRM maintained by the ATF. The IBIS correlation scores thus obtained may be compared against consensus scores arrived at by a panel of IBIS operators under the National Ballistics Imaging Comparison (NBIC) project.

Alternatively, users of systems that directly measure surface topography may compare the acquired topography images with reference topography images maintained by NIST and available on the Website, pml.nist.gov/srm2461. Two properties of the surface topography are used to characterize the similarity of the cartridge case surface topography images: the areal cross correlation function maximum $ACCF_{max}$ and the signature difference D_s. The certified values for these parameters are obtained from statistical correlations between the surface topography of breech face, firing pin and ejector mark regions of the SRM 2461 cartridge cases and those of a reference standard, comprised of the surface topography of breech face impression, firing pin impression and ejector mark captured respectively from three reference SRM cartridge cases. When two correlated cartridge case signatures are exactly the same (point by point), D_s must be equal to 0 and $ACCF_{max}$ must be equal to 100 %.

All units of the SRM as well as the reference images were measured with a confocal microscope at NIST. The topography images went through bandpass filtering to minimize form and waviness and to emphasize the fine roughness features of these measured topographies. The topography images were then correlated with those of the three reference standards. For all three regions of the 137 SRM cartridge cases being distributed, the lower limit for $ACCF_{max}$ and upper limit for D_s, each with a 95 % confidence level (α = 95 %) are reported in Table 1.

Table 1. Areal Cross Correlation Maximum $ACCF_{max}$ and Signature Difference D_s for the SRM 2461 Standard Cartridge Cases

	$ACCF_{max}$	D_s
Breech Face	> 94.3 % (α = 95 %)	< 11.2 % (α = 95 %)
Firing Pin	> 98.0 % (α = 95 %)	< 4.0 % (α = 95 %)
Ejector Mark	> 93.7 % (α = 95 %)	< 12.2% (α = 95 %)

All uncertainty components are judged to result in Type A variations in the topography images and in Type A variations when the cartridge case topography images are correlated with the reference images. Hence, all the uncertainties in the measurement system are directly estimated by the observed Type A variations of the parameters, $ACCF_{max}$ and D_s.

*Certain commercial equipment may be identified in this abstract in order to specify an experimental procedure. This does not imply recommendation or endorsement by NIST, nor does it imply that the equipment are the best available for the purpose.

Key Words: ballistics, surface topography, cartridge cases

Author Bios:
T.V. Vorburger, A. Zheng, T. B. Renegar, J.F. Song, and J. Villanova are with the Semiconductor and Dimensional Metrology Division, J. Yen is with the Statistical Engineering Division, L. Ma is with the Metallurgy Division, and R.M. Thompson is with the Law Enforcement Standards Office at NIST. Wei Chu is with Intelligent Automation, Inc., Rockville, MD. M. Ols is with the National Laboratory Center of the ATF in Ammendale, MD

4:00 – 4:20 The National Ballistic Imaging Comparison Parts 1 and 2

Authors:

Alan Zheng Robert M. Thompson John Song Thomas Brian Renegar James Yen, PhD Theodore Vorburger, PhD Susan Ballou Address for all authors/co-authors: NIST, 100 Bureau Drive STOP 8212, Gaithersburg, MD 20899

Title

The National Ballistic Imaging Comparison Parts 1 and 2

Learning Objective

After attending this presentation, attendees will understand the importance of having a unified and traceable quality assurance standard for the IBIS systems in their crime labs. They will also understand how NIST developed the SRM2460 Standard Bullet and SRM2461 Standard Casing as well as how NIST established a control limit for the IBIS systems when measuring the SRM2460/SRM2461.

Impact Statement

This presentation will impact the forensic community and/or humanity by establishing a set of minimum control limits for the IBIS system when it measures a Standard Bullet or Casing. Using a unified quality assurance standard allows inter-laboratory comparisons, proficiency testing, instrumentation testing. With the standards in place, the overall quality of evidence bullet and casing entries in the IBIS system will improve.

Abstract

In response to the guidelines issued by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB-International) to establish traceability and quality assurance in U.S. crime laboratories, a NIST/ATF joint project entitled National Ballistics Imaging Comparison (NBIC) was initialized in 2008. The NBIC project aims to establish a National Traceability and Quality System for ballistics identifications in crime laboratories within the National Integrated Ballistics Information Network (NIBIN) of the U.S. NIST Standard Reference Material (SRM) 2460 Bullets and 2461 Cartridge Cases are used as reference standards. 19 ballistics examiners from 13 U.S. crime laboratories participated in this project. They each performed 24 periodic image acquisitions and correlations of the SRM bullets

and cartridge cases over the course of a year. NBIC 2 was initiated in 2012 with similar goals aimed at the new IBIS BulletTrax casing measurement system. In this study, only the SRM2461 Standard Casing was used. More than 17 examiners from 11 U.S. crime laboratories participated in this project. They each performed 17 measurements of the breech face, firing pin, and ejector mark over a 6 months period. The correlation scores were collected by NIST for statistical analysis, from which control charts and control limits were developed for the proposed Quality System and for promoting future assessments and accreditations for firearm evidence in U.S. forensic laboratories in accordance with the ISO 17025 Standard.

Keywords

Traceability, IBIS, QA

Author Bio

Alan Zheng is a Mechanical Engineer with the Surface & Nanostructure Metrology Group in the National Institute of Standards and Technology (NIST). He has a B.S. in Mechanical Engineering from University of Maryland Baltimore County as well as a M.S. in Mechanical Engineering from Johns Hopkins University. He has been with the group since 2003 and has worked on many forensic projects related to 3D topography acquisitions and correlations of ballistics evidence. He also has extensive experience in both contact (stylus) and non-contact (optical) surface metrology.

4:20 – 4:40 Models for Firearm Impression Cross-correlation Scores

Authors:

James H. Yen, Ph.D., Statistical Engineering Division, National Institute of Standards and Technology, Gaithersburg, MD 20899

Title

Models for Firearms Impression Cross-correlation Scores

Learning Objective

Attendees will learn about statistical analyses of ballistics similarity scores, including graphical methods, overlap metrics, and mixed-effects models, all of which will be applied to describe manufacturer effects in ballistics identification data.

Impact Statement

The presentation will augment the forensic community's understanding of ballistics correlation scores, and will highlight the approach used to find various effects.

Abstract

Firing pin and breech face impressions are examples of the marks and impressions left on a cartridge case left by firearms. The degree of similarity between impressions left on different cartridge casings can be summarized in similarity, or correlation, scores. Correlation scores can be used in database searches to find those casings that are most similar to evidence casings found at crime scenes.

Ideally, correlation scores of casings and bullets from the same gun (called matches) should be higher than those from different guns (non-matches). We explore some theoretical models for the maximum areal-cross correlation scores that have been used in some NIST applications. Variance component and mixed-effects models are touched upon, as is the effect of filtering.

Finally, we look at some results from the NIST Ballistics Imaging Database Evaluation (NIBIDE), which produced a set of 108 casings fired from twelve 9mm pistols. The resulting cross-correlations were analyzed using graphical and statistical techniques, including visualization of correlation matrices. We examine differences between match and non-match scores from that experiment, as well as possible effects from the different ammunition and firearms manufacturers used.

While these results are particular to a specific ballistics correlation scheme, the general approach should be applicable to other scenarios and fields where similarity/dissimilarity scores for matching and non-matching specimens are utilized.

Keywords

Firearms, correlations, Statistics

Author Bio

James H. Yen has been a Mathematical Statistician since 1997 in the Statistical Engineering Division of the Information Technology Laboratory at N.I.S.T. He has a Ph.D. in Statistics (1997) from Stanford University. He works in statistical data analysis and computing in a wide variety of fields. Since 2003, he has been collaborated in projects related to Forensics at NIST, including the Ballistics Imaging Database Evaluation (NIBIDE) and the National Ballistics Imaging Comparison (NBIC).

November 29, 2012 – Day Two

Trace Analysis/Collection Session – Green Auditorium

9:00 – 9:30 INTRODUCTION: Microchemistry and Microanalysis in Trace Evidence

Authors:

Eric B. Steel*, John A. Small, Surface & Microanalysis Science Division, National Institute of Standards & Technology, Gaithersburg, MD 20899

Title

Microchemistry and Microanalysis in Trace Evidence

Learning Objective

This paper presents an overview of microchemical and microanalysis approaches taken by the

NIST Materials Measurement Laboratory, MML research efforts and measurement services impacting trace-evidence, and gives the forensic community an understanding of how NIST works and how our measurement services may be coordinated with their efforts to create reliable, validated, standard sampling and analysis systems.

Impact Statement

This presentation gives the forensic community an understanding of how NIST works and how our measurement services may be coordinated with their efforts to create reliable, validated, standard sampling and analysis systems

Abstract

Trace evidence analysis is a difficult forensic area due to the broad and unpredictable classes of materials that are found at crime scenes and associated with suspects. From spores of a biothreat agent to traces of nuclear materials to automotive paint and glass to threads of clothing, the sampling and analysis approaches needed are as varied as the materials. But as difficult as it is, sometimes trace evidence is the only physical evidence identified and can therefore be critical to closing a case. NIST has activities and expertise across this broad spectrum of materials characterization and often specific knowledge in particular forensic trace-evidence application areas. NIST works with the analytical and enforcement communities to create systems of reliable methods, reference materials, reference data, and simulation/modeling approaches that enable labs to accurately answer the analytical challenges of trace evidence. This paper presents an overview of microchemical and microanalysis approaches taken by the NIST Materials Measurement Laboratory. We will cover MML research efforts and measurement services impacting trace-evidence and give the forensic community an understanding of how NIST works and how our development of measurement services may be coordinated with their efforts to create reliable, validated, standard sampling and analysis systems.

Keywords

Trace-evidence, Microanalysis, Standards

Author Bio

Eric Steel has been responsible for developing over 20 NIST reference materials, two of NIST's largest laboratory accreditation programs, and many documentary standards through Standards Development Organizations (including ANSI, ASTM, and ISO). He has a technical background in chemical imaging and microanalysis with emphases in forensics, nanotechnology, national security, particle characterization, and environmental applications.

Trace Sampling

9:30 – 9:50 Enabling Forensics Investigations of Biothreat Incidents through Sampling Standards and Field Capability Building

Authors:

Jayne Morrow, Lindsay Vang, Autumn Downey, Sandra Da Silva, Nathanael Olson
Biochemical Science Division, NIST

Title

Enabling Forensics Investigations of Biothreat Incidents through Sampling Standards and Field

Capability Building

Learning Objective

The focus of this talk will be to introduce the NIST scientific community to the challenges of collecting suspected biothreat samples, field response capabilities and demonstrate biothreat response to support a forensics investigation. Attendees will have broad perspective on the current state of biothreat response and hands on experience with the challenges with evidence collection and coordination following a suspected biothreat event.

Impact Statement

Improving collection procedures and coordination guidance is critical to confirming a biological threat incident and providing useful evidence for any follow on microbial forensics investigations.

Abstract

Since the letters laced with Bacillus anthracis spores were mailed in 2001, U.S. law enforcement entities have responded to over 30,000 incidents involving suspicious samples. Emergency responders still receive calls on a daily basis throughout the U.S. involving suspicious powder materials. Frequently the emergency responders are tasked with assessing the samples in the field. Response to any suspected biothreat incident is critically connected to a microbial forensics mission if the material is deemed a credible biothreat by the Federal Bureau of Investigation (FBI). Stakeholders from across the U.S. including the Centers for Disease Control and Prevention (CDC) and the FBI recognize that to support responders in their mission to collect and assess suspicious biological materials and take appropriate public safety actions based on the result requires voluntary consensus standards for (1) a concept of operations; (2) training and certification of the responder; (3) proficiency testing of the responder; (4) sample collection; and (5) a certified detection technology.

NIST has had a considerable effort investing in the guidelines, standards and materials utilized by first responder professionals throughout the various phases of response including the state and local HazMat crews, civil support teams, coast guard or other military personnel and federal agencies including the CDC, FBI, and Environmental Protection Agency. There has been an increase in the quality of data obtained from sampling in accordance with standards and current efforts to develop National Strategies for response to biothreats providing the assurance to first responders, Federal law enforcement and emergency personnel, and remediation technicians. NIST standards efforts (e.g. ASTM 2770), allow the responders to measure the relevant properties of the materials, establish detector performance in the field, sampling techniques for rapid threat assessment and methods and measurements to make meaningful decisions with a high degree of confidence in detection capabilities that enabling a more rapid forensics investigation.

Keywords

biothreat, sampling, standards

9:50 – 10:10 Surface Wipe Sampling for Trace Narcotics and Explosives Collection – Jennifer R. Verkouteren, PhD, Surface and Microanalysis Science Division, MML

Abstracts not submitted

10:10 – 10:30 The Development of an Aerodynamic Sampling System for Photo-Identification Cards

Authors:

Matthew Staymates, Jessica Staymates, and Greg Gillen. The National Institute of Standards and Technology

Title

The Development of an Aerodynamic Sampling System for Photo-Identification Cards

Learning Objective

This presentation will provide an overview of a prototype device that is designed to sample an identification (ID) card or badge for trace levels of contraband material like explosives or narcotics.

Impact Statement

By attending this presentation, the audience will learn about emerging technologies that enable enhanced security screening by leveraging non-contact aerodynamic sampling with forensic identification.

Abstract

This presentation will provide an overview of a prototype device that is designed to sample an identification (ID) card or badge for trace levels of contraband material. The ID Sampler uses high-velocity impinging air jets to liberate particulate material from the ID and then transport the material to a particle collector using a high-pressure blower. This is a front-end sampling device that does not contain a chemical analyzer. A commercial chemical trace detector is required for a complete and useful system. In its current configuration, the collection system consists of a unique particle impactor with a removable cartridge that contains a trace detection collection swab. The particle impactor was developed using computational fluid dynamics to streamline the aerodynamic performance of the impactor while minimizing the pressure drop across the collection plate. The impactor has a theoretical particle cut-off diameter of 2.4μm. Both the particle impactor and the ID Sampler chamber were built in a 3D printer system which allows for rapid modification and redesign of research prototypes. We are currently evaluating our latest prototype that includes a total of four airblade slots that apply aerodynamic shear stress along the length of an ID card. Experimental results of particle removal efficiency for our first ID Sampler design (with only two airblade slots) showed an average removal efficiency of 20% at locations closest to the airblades. In this presentation, we will discuss the results of the second ID Sampler prototype. Finally, we plan on incorporating the latest in biometric scanning technology into the ID sampler as a trigger to start the analysis. We also plan on integrating an ultraviolet light source and detection camera which will give operators an idea of the authenticity of the ID card. When the biometric scanning and UV detection is operational, the

security operator using the ID Sampler will know who you are, if you are who you say you are, if your ID is counterfeit, and if you have been handling explosives or narcotics.

Keywords

sampling, explosives, detection

Author Bio

Matthew Staymates is a fluid dynamicist and mechanical engineer at the National Institute of Standards and Technology

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Standard Test Materials/Operational Protocols

10:50 – 11:10 Production of Seized Drug Analysis Standards through Inkjet Printing Technology

Authors:

Jeanita S. Pritchett, Ph.D.1*; Karen W. Phinney, Ph.D.1; Jennifer R. Verkouteren, Ph.D.2
National Institute of Standards and Technology 100 Bureau Dr, Gaithersburg MD 20899 1. Analytical Chemistry Division MML 2. Surface and Microanalysis Science Division MML

Title

Production of Seized Drug Analysis Standards through Inkjet Printing Technology

Learning Objective

Through this presentation, attendees will learn about the development and optimization of inkjet printed designer drug standards, ideal substrates for printing such standards, and their stability over time and at various storage conditions.

Impact Statement

Development of inkjet deposited designer drug standards will provide the forensic community with cost effective, low manipulation, single use materials to help confirm the identity of drugs of abuse.

Abstract

The availability of standards that can be used to help confirm the identity of drugs of abuse continues to be a challenge for forensic laboratories, particularly in the area of designer drugs. A limited number of standards are available commercially, and even fewer standards can be obtained as certified reference materials (CRMs). Hence, laboratories are often faced with preparing in-house reference standards, either by chemical synthesis or through isolation of the desired compound from seized materials. The desire is to develop a mechanism to provide cost effective, easy to use standards for seized drug analysis by GC-MS or LC-MS(/MS). This work employs inkjet printing technology to deposit known amounts of pure substances, or mixtures of substances, onto an inert surface via picoliter sized droplets. At the time of use, the compound would be desorbed from the surface by rinsing with a small amount of solvent. Determination of parameters such as substrates and solvents for printings, suitable drug compounds for this methodology, as well as quantities of deposited drug compounds needed for desorption and use with the aforementioned analytical techniques are the initial focus. Furthermore, the stability of the printed compounds on different substrates stored under varying conditions is being investigated. The potential advantages of this approach relative to current practices include the

fact that only a very small amount of the compound is needed for each printed standard, and the printed standards could be considered as single use materials, so that any potential contamination from multiple uses of the same batch of material is eliminated.

Keywords

inkjet printed standards

Author Bio

Jeanita S. Pritchett obtained her Ph.D. in Analytical Chemistry from the University of Illinois at Chicago in 2011. She began working at the National Institute of Standards and Technology (NIST) as a National Research Council Post Doctoral Research Fellow in May 2011. During her time at NIST, Jeanita has worked on various research projects in both the forensic and toxicology fields.

11:10 – 11:30 Nuclear Forensic Reference Materials (RM) for Attribution of Urban Nuclear Terrorism

Author:

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Title

Nuclear Forensic Reference Materials (RM) for Attribution of Urban Nuclear Terrorism

Learning Objective

Attendees will be introduced to nuclear forensics, why is it important, why reference materials (RMs) are important for the nuclear forensics mission (measurements and legal), what NIST is doing to support the nuclear forensics mission using the urban vitrified composite (UVC) as an example, as well as what future projects NIST is considering.

Impact Statement

The audience will have 1) a better appreciation for NIST's role in nuclear forensics and the delivery of nuclear forensics RMs, 2) an understanding of how we can support pre-detonation to post-detonation nuclear forensics programs with RMs so they can better advocate for the RMs needed for their programs and provide NIST RM feedback, and 3) an idea as to the cost savings that can be had with RMs serving multiple nuclear forensics programs.

Abstract

Preventing and responding to nuclear terrorism (Improvised Nuclear Device, Radiological Dispersal Device, Radiological Exposure Device) is the top combating weapons of mass destruction issue for the United States. The consequences of a successful nuclear terrorism event are: >$50B cost per event or economic collapse, national psychological blow, loss of international stature, political chaos, loss of liberties, and an embolden enemy. Nuclear forensics is a new component to the traditional forensic discipline and provides material characterization of a weapon's matrix, chemical form [metal, oxide, particle indicating fuels, boosting], isotopic composition [indicating fuels, boosting, reactor type, length of irradiation, reactor power, recycling of fuel, time of last separation, reprocessing], trace radionuclide signatures [indicating weapon sophistication, reactor power], trace element signatures [indicating processing, reprocessing], and fission products [indicating energy of neutrons, boosting]. A number of Agencies are deeply involved in countering nuclear terrorism including DOJ, DHS, CIA, DOE, DoD, DIA, and the IAEA each that have developed programs encompassing CBRNE Intel, Validation, Interdiction, Elimination, National Security, Non-Proliferation Treaty verification, Open Skies (observation flights), Fissile Material Cutoff Treaty, Cooperative Threat Reduction, New Start (stockpile reduction), Strategic Offensive Arms Reduction Treaty, and the US-International Atomic Energy Agency Safeguards Agreement. Reference materials provide the underlying measurement support for high fidelity attribution capabilities of an urban nuclear terrorist event. This effort will focus on the characterization of an urban vitrified composite (UVC) doped with enriched uranium to test the U.S. nuclear attribution capabilities. This UVC material is a homogenous composite of minerals and metals characteristic of the concrete, steel and building materials and U or plutonium (Pu) debris exposed to a nuclear detonation and mimics the rubble samples collected for forensics evidence and attribution. Additionally, because post-detonation samples would also contain short-lived fission products from the U or Pu in the nuclear weapon, the UVC has been doped with a known amount of U or Pu which upon exposure to known neutron fluence will cause the encased U or Pu atoms to split and quantitatively yield short-lived fission products. The resulting irradiated UVC glass is chemically similar to samples generated in an actual detonation, thus serving as a RM for nuclear forensic post-detonation measurements. The technical plan consists of: 1) Assess the micro-homogeneity of UVC material employing non-destructive micro-XRF for evaluation of suitability as a RM; 2) Develop microwave digestion and fusion dissolution protocols for preparation of the UVC sample for elemental and isotopic analysis; 3) Determine elemental and actinide massic concentration of the UVC using isotope dilution and standard additions approaches combined with HR-ICP-MS; 4) Stable isotopic analysis for "fingerprint" identification also employing HR-ICP-MS; 5) Delivery of evaluation of results in peer-reviewed articles, reports, and Certificates on dissolution procedures, elemental and isotopic analysis, and efficacy of UVC as post-detonation RM material; and 6) Provide Certificate of UVC elemental and isotopic mass determinations.

Keywords

nuclear, standard, attribution

Author Bio

KENNETH G.W INN - ENVIRONMENTAL RADIOCHEMISTRY. Ph.D., Univ. of Arkansas, 78; Research Chemist, NBS, 78-88; Scientific Assistant ,NBS NML, 88-89; Scientific Assistant, U.S. DoC Undersecretary of Tech; 89-90; Scientific Assistant, NIST CRR, 90-91; Staff

Radiochemist, MACTEC, 91-92; Group Leader, Office of Radiation Measurements, 92-94; Project Leader, Environmental Radiochemistry, 95-present. Rep: NTNFC POC, 08-Present; FRPCC R/D Chair 08-12; Advisor, U.S. TransU and U Registries, '89-95; Mem: Am. Chem. Soc.; Geochem. Soc.; Sigma Xi, 97-12. He directs programs in low level radionuclide environmental matrix Standard Reference Materials, radionuclide speciation in soils and sediments, and low level radiochemistry traceability evaluations.

11:30 – 11:50 Following the Scent: Development of Canine Training Aids Guided by Measurements

Authors:

William MacCrehan*, Stephanie Moore, Michele Schantz. Analytical Chemistry Division, NIST

Title

Following the scent: Development of Canine Training Aids Guided by Measurements

Learning Objective

To see how measurement technology can support forensic science; conceptualize the important factors in developing canine training aids

Impact Statement

Sophisticated vapor-time measurements provide a scientific basis for the development of optimal training aids, replacing an entirely empirical approach

Abstract

Canines play an important role in the detection/location of explosives, drugs-of-abuse, cadavers, and suspects – naming only a few applications. Dogs may be trained to detect levels of vapors/odors that are far below the capabilities of field-able analytical instrumentation. A key element in successful canine detection is the use of effective training aids. However, providing uniform training materials for contraband items such as explosives is expensive, requiring chain-of-custody documentation, explosive storage magazines, and trained explosives personnel. This limits access to these critical training materials, especially for state and local K-9 teams. The development of validated, non-explosive training aids that provide the key odor signature of explosives could reduce the need for the costly and hazardous use of real explosives in canine training. Three elements are needed to design effective non-explosive training aids: a measurement technology to characterize the odor profile of real explosives and training aid materials over time; development of non-explosive training aid materials providing the identified critical odors; and testing and validation of the training aid materials with bomb dogs. To address the first element, a measurement approach that allows the reproducible characterization of the vapor profile of a sample as a function of time called SPME-ESIS has been developed. SPME-ESIS works by alternatively sampling an invariant vapor provided by an internal standard followed by sampling the analyte in the test sample using Solid-Phase MicroExtraction. Indexing the analyte response to the internal standard (the Externally-Sampled Internal Standard) provides a means to eliminate the variability associated with SPME fiber irreproducibility as well as drift of the GCMS response, allowing reproducible sampling for

several days. To determine this indexed response, the ratio of the peak area of the analyte is divided by the internal standard area (A/E ratio). Periodically determining A/E allows the reproducible monitoring of the vapor of the test sample as a function of time. Monitoring the A/E ratio allows one to compare the vapor-time profile of an explosive and test materials on an equivalent basis. In developing an ideal training aid, the material would provide the signature odors of the real explosive, provide a steady concentration of those vapors, and have a long lifetime for vapor release. We have initially focused on the plastic explosives C-4 and Semtex as well as the improvised explosive TATP(triacetone triperoxide). A number of approaches have been investigated for preparing training aids. The explosives have been coated onto adsorbant particles, spiked from solution onto filter paper and adsorptive filters, and 'infused' into an absorbant polymer. Each explosive and test material is placed in a container that simulates the configuration of a canine training aid, allowing the vapors to escape into the room. The SPME-ESIS measurements of the vapor-time profiles are then compared over a period of 3 days. Each material provides a unique profile differing in magnitude and decay time. For example, the highly volatile compound TATP, when spiked from solution into a training aid container, provides an initially high amount of TATP vapor but only lasts for about a day. Coating TATP on a solid adsorbant provides somewhat less TATP vapors initially and steadily declines over 3 days. One particularly promising approach is based on infusing the volatile components into the easily-prepared polymer PDMS (polydimethylsiloxane). We have tested a number of approaches to infusing the polymer including blending in known canine odorant compounds before curing, spiking the polymer with a solution of the odorant, or just allowing the polymer to be suspended over the explosive in a closed container for about a month. This last approach is particularly promising as it captures all volatile components associated with the explosive by absorption. A priori knowledge of the composition of the explosive is not required. Once infused, the polymer may then be exposed in a training aid container to release a complex odor profile, albeit at much lower amounts than was provided by the parent explosive. This 'capture and release' technology is not limited to explosives and may be used for the detection of drugs-of-abuse and arson investigations. The Department of Homeland Security Science and Technology Directorate funded the production of the work presented in this material under HSHQDC-10-00297 with NIST.

Keywords

canine training aid

Author Bio

As an analytical chemist with NIST for 35 years, Dr. MacCrehan has developed new measurement technology as diverse as measuring organometals in fish tissue, nitroaromatics in diesel soot, sulfidic compounds in Chesapeake Bay sediments, chlorination products of pharmaceutical compounds in wastewater, and organic gunshot residue. He has spearheaded a project to develop documentary and artifact standards (standard reference materials SRMs) for trace explosives detector validation. NIST now provides 3 SRMs for trace explosives addressing C-4, TNT, TATP, and Semtex. Recent research has focused on development of measurement technology and new materials as non-explosive training aids for bomb dogs.

11:50 – 12:10 Performance Validation for Trace Detection of Contraband Using Inkjet Printing, Cloud Computing and a Standard Interferent Dirt

Authors:

R. Michael Verkouteren, PhD, Material Measurement Laboratory, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, Maryland 20899-8371 USA

Title

Performance Validation for Trace Detection of Contraband Using Inkjet Printing, Cloud Computing and a Standard Interferent Dirt

Learning Objective

Principles and strategies behind trace detection of explosives and drugs-of-abuse will be described, as well as the challenging practical and technical aspects of effective performance validation involving nanogram to picogram quantities of analytes in complex natural matrices.

Impact Statement

The trace explosives/narcotics standards program at NIST supports the wide-scale deployment of trace detectors in the US and abroad. We develop methods and materials that help first responders, military personnel, security officers and forensic specialists to test, tune and validate their sampling methods and detectors to screen effectively for contraband. This work directly impacts the safety of the public and the quality of life, the security of the national infrastructure, and the economic health of the United States, and has been funded by the Department of Homeland Security, the Transportation Security Laboratory, and the NIST Office of Law Enforcement Standards.

Abstract

In the field, trace detectors are typically deployed in less-than-ideal conditions. Particulate matter such as dusts usually contaminate the sampled surfaces, potentially influencing detection performance. To develop an effective and standardized method for validating the performance of trace detectors, we have focused on three diverse and novel projects: (1) the adaptation of inkjet technology to print trace analytes on substrates; (2) the development of a robust method for determing limit of detection (LOD) and a web-based "cloud computer" for performing the calculations; and (3) the formulation of a standard simulated "dirt" (SIMdirt) for challenging trace detectors with a realistic interferent. Each project is briefly described in turn below. Drop-on-demand inkjet printing was developed [1] to allow precise (within 1 %) and accurate (within 4 %) dispensing of picogram to nanogram quantities of analytes in realistic patterns on sample substrates. Using these substrates as reference materials, detector responses may now be calibrated across their full dynamic range without the otherwise significant confounding influence of deposition uncertainty. The ASTM E54.01 subcommittee on CBRNE Sensors and Detectors for Homeland Security Applications is developing a Standard Method for the determination of LOD in trace contraband particle detectors. Based on NIST measurements performed on many models of trace explosives detectors, a robust statistical method was designed [2]. This method is currently being coded and tested on a public-facing web site that will allow the input of measurement data and have the estimate of LOD calculated remotely and returned to the user. This Standard Method, when promulgated by ASTM, will provide a well-documented metric of detector performance, while the web-based calculator provides a standardized means to perform the otherwise difficult calculations via a Cloud Computing portal.

The SIMdirt was prepared by blending four NIST natural matrix Standard Reference Materials (SRMs), and formulated to produce background effects similar to those observed in deployed trace detectors. We have measured the performances of many types of trace detectors using inkjet-produced reference materials with and without the addition of the SIMdirt, and found that effects were reproducible when the validation methods were judiciously designed. Surprisingly, LOD values for many analytes were not significantly affected by low levels of SIMdirt in well-functioning detectors. Together, these three projects enable the development of robust validation methods for testing the performance of trace contraband detectors under realistic conditions. Test materials for any trace analyte may be produced by inkjet printing on suitable substrates, and the resulting measurements may be evaluated consistently through the web-based portal that calculates the LOD performance metric according to a proposed ASTM Standard. User communities are free to customize detector validation methods based on LOD requirements for the detection of certain compounds, and require attainment of those LOD values under specified loadings of SIMdirt or other standard interferent material. [1] R.M. Verkouteren and J.R. Verkouteren, Analytical Chemistry 81 (2009) 8577-8584; Langmuir 27 (2011) 9644-9653. [2] A.L. Rukhin and D.V. Samarov (2011) Chemometrics and Intelligent Laboratory Systems 105, 188-194.

Keywords

Interferent, Trace, Validation

Author Bio

R. Michael Verkouteren received his B.S. degree from Tufts University and Ph.D. from Purdue University (1984). Since then, he has worked in the Microanalysis Science Division of NIST, focusing on research and standards development projects of importance to US industry, the environment, and homeland security. For the past nine years his work has focused on the trace analysis of explosives, where he has developed reference materials and metrics for testing detector performance using ink jet technology.

12:10 – 12:30 NIST Trace Explosives Test Bed

Authors:

Marcela Najarro, Jennifer Verkouteren, George Klouda, Matt Staymates, Jessica Staymates, Mike Verkouteren, Robert Fletcher, Eric Windsor and Greg Gillen

Title

NIST Trace Explosives Test Bed

Learning Objective

To understand the role of measurement science and analytical standards to improve the reliability and effectiveness of trace explosives detection.

Impact Statement

The NIST Entry Point Screening Test Bed provides researchers with a platform to evaluate real-world instrument performance issues such as false alarms, background contamination, environmental conditions and sample throughput.

Abstract

There is a critical need to protect government infrastructure from potential terrorist threats. Government agencies have expanded security measures by increasing surveillance, manpower and threat detection capabilities. The National Institute of Standards and Technology (NIST), Surface and Microanalysis Science Division, focuses on the development of measurements and standards that facilitate improvements in the reliability and effectiveness of currently deployed explosives trace detectors (ETDs) and next-generation detection technologies. Ion mobility spectrometers (IMS) - based ETDs are widely used for the rapid screening of trace explosives and narcotics residues collected by physical swiping of a suspect surface. In this technique, residues collected on a sampling swipe are thermally desorbed by rapid heating to produce neutral vapor molecules that are subsequently ionized with a 63Ni source at atmospheric pressure. Although extensive research is focused on the development of next-generation technology, long-term evaluation of instrument field performance is a need in the area of trace explosives detection. We have recently focused new efforts in the development of a NIST Trace Explosives Ted Bed. The goal of this field test bed is to test NIST laboratory findings in real-world field conditions to determine end-user utility and provide stakeholders with operation improvement recommendations (OIRs). The development of the test bed has involved the deployment of trace detection systems throughout the NIST campus. In addition, a training program has been developed and implemented for NIST Physical Security. Laboratory research findings have been integrated into the training program including standard operating procedures for proper instrument operation and best practices for sample collection and alarm resolution. To date, over 40 NIST security clerks/police officers have been trained in the daily operation and maintenance of explosives trace detectors. Field experiments with our trained officers have yielded data supporting the improvement of collection media (swabs) as well as hand-held wands used to harvest a sample. In addition, researchers provide field screeners with well-characterized explosives test materials used daily to validate instrument performance under operational environmental conditions. Inkjet printing technology capable of depositing a known mass of explosive with better than 1 % precision is used to produce the quality assurance/quality control (QA/QC) test materials. We are evaluating the stability of the test materials as well as testing different storage methods to establish sample shelf-life. Analytical figures of merit such as measurement repeatability and instrument sensitivity are evaluated as part of our analysis. Preliminary QA/QC results of ETDs deployed at the NIST test bed show typical measurement repeatability of approximately 10 % RSD, when n = 5 using these high-level test materials. In summary, the ability to compare field data versus laboratory data allows us to compare factors such instrument drift, environmental effects, test material stability in the field, monitor need for maintenance of the detectors as well as compare instrument response and measurement repeatability. Operational improvement recommendations developed through our test bed are now being leveraged by stakeholders in a series of pilot studies to determine their value for airport security screening. In the future we hope to expand our test bed to take advantage of other resources we have on campus such as an explosives canine team and a cargo-screening facility.

Keywords

explosives, trace, detection

Author Bio

Marcela Najarro has been a research chemist at NIST since 2005. Her professional background is in Forensic Chemistry/Toxicology, with an emphasis in the detection and identification of

drugs of abuse. Her current research interests include the generation of trace explosives standards to verify the proper operation of Ion Mobility Spectrometry (IMS) instruments, establish detector response criteria, and be used for calibration purposes. This effort includes developing and validating methods for the high precision quantification of trace explosives standards using Gas Chromatography/Mass Spectrometry and Ultraviolet-Visible spectroscopy (UV/Vis) and the evaluation of multi-variable data sets using statistical analysis.

12:30 – 12:50 Mass Spec Reference Libraries for Forensics: Past, Present and Future

Authors:

NIST Mass Spectrometry Data Center Team, presented by Steve Stein

Title

Mass Spec Reference Libraries for Forensics: Past, Present and Future

Abstract

Determining the identify of compounds in a mixture is often a critical task in forensic analysis. For compounds that are volatile or can be made volatile by chemical treatment, library searching of spectra acquired by GC/MS provides the 'gold-standard' means of identification. Matching spectra to a reference library is a key step in the process. NIST has long provided a comprehensive library for this purpose (the "NIST/EPA/NIH Mass Spectral Library"). In more recent years, the method of LC/MS and related 'ambient' methods have extended the range of compounds identifiable by spectrum matching – in response, NIST has developed a library of 'tandem mass spectra'. These NIST libraries and the tools provided with them are widely used in forensic and other labs to assist in critical identification tasks. In this presentation we describe the development and use of these libraries and related tools, focusing on forensic applications. We will also describe libraries and applications under development that promise to significantly extend the ability to analyze complex mixtures.

Technique Development for Trace Evidence

2:20 – 2:40 Optimizing Forensic Automated Particle Analysis

Authors:

Nicholas W. M. Ritchie, NIST, Microanalysis Group

Title

Optimizing Forensic Automated Particle Analysis

Learning Objective

Improve the throughput of forensic automated particle analysis.

Impact Statement

Improving throughput can reduce the case backlog.

Abstract

A gun-shot residue (GSR) sample backlog is one of the problems common to many of forensic labs which support automated particle analysis by scanning electron microscope with energy dispersive spectrometer (APA by SEM-EDS). Searching for the needle-in-the-haystack particle characteristic of gun primer requires significant instrument time. A single sample may take many hours regardless of whether a single particle of interest is discovered. Improving the throughput of APA by SEM-EDS is an optimization game. Numerous different tasks contribute to the total time budget. On most samples, the largest amount of time is typically spent collecting x-ray spectra on each particle. Depending upon the characteristics of the instrument and the sample, searching for particles and moving the stage can also represent significant time sinks. The current state of the art for commercial instruments is an optimized net throughput of about 1,000 particles per hour. We are working with a commercial SEM-EDS vendor to develop an instrument optimized for automated particle analysis. While the current state-of-the-art system has a single x-ray detector capable of measuring approximately 20 kcps/nA on bulk copper, the new system with four x-ray detectors together capable of ten times this throughput. In addition, the new system is capable of collecting an x-ray spectrum image on each particle. This will permit the system to distinguish inhomogeneous particles. The imaging performance of the new system was also optimized for high throughput. While the current system is capable of searching for particles with dwell times of 8 µs/pixel, the new one has an optimized detection system capable of dwell times of 1 µs/pixel. Similarly, the stage motion is optimized. The net result is a system that is capable of at least 7,500 particles per hour. A system with this speed could quickly and cost-effectively cut through most GSR sample backlogs.

Keywords

GSR, SEM, EDS

Author Bio

Nicholas W. M. Ritchie is a physicist in the Microanalysis Group. His interests include electron beam x-ray microanalysis of particles and bulk samples and numerical simulation. Before joining NIST, he lead software development at a scanning electron microscope vendor where among other things he lead the development of commercial software for automated gun-shot residue (GSR) analysis.

2:40 – 3:00 Combined Chemical and Biometric Field Analysis of Human Fingerprints

Authors:

Jessica Staymates, MFS*†, Shahram Orandi, MS‡, Greg Gillen, PhD† National Institute of Standards and Technology †Surface and Microanalysis Science Division ‡Information Technology Laboratory Gaithersburg, MD 20899

Title

Combined Chemical and Biometric Field Analysis of Human Fingerprints

Learning Objective

This presentation will introduce this novel approach of combining trace contraband detection with biometrics for field applications. Having the ability to collect a latent print and heat it for chemical analysis while keeping the print intact could be extremely useful for law enforcement and military operations. It could potentially reduce the cost and delay of sending fingerprint

samples to a lab for chemical analysis. Chemical analysis in the laboratory may also affect the ability to analyze the fingerprint for biometric purposes.

Impact Statement

This work is beneficial to the forensic community by offering a unique latent fingerprint collection method that is compatible with quick field-deployable chemical analysis techniques that are currently in use around the globe.

Abstract

There are currently several existing methods to collect and analyze latent fingerprints for human identification with forensic applications. There are also numerous techniques to collect and detect trace levels of contraband materials from various surfaces within a few seconds. However there is not yet a field deployable technique to collect a latent fingerprint and investigate that print for trace explosives or narcotics contamination in the field within a single sample. Here we describe a method to collect latent fingerprints and analyze them with a common trace contraband detection technique, ion mobility spectrometry (IMS). IMS is a rapid screening technique commonly used in airports, prisons, and border control checkpoints to examine various surfaces for trace levels of explosives or narcotics. Surfaces are typically swiped with a collection material to collect microscopic particles, and the swab is then heated to temperatures exceeding 200°C for analysis. Adding a heat-sensitive and low out-gassing silicone adhesive to the collection swabs has been shown to improve the particle collection efficiency by a factor of 12 [1]. This adhesive can also be applied to a surface for collecting a latent print, and, due to its heat resistance, is compatible with trace detection techniques such as IMS. Collection swabs for lifting fingerprints were made by applying a heat-resistant silicone adhesive to opaque smooth Teflon swabs. Latent fingerprints containing trace levels of C-4 explosive were created by a volunteer on glass slides, and forensic magnetic fingerprint dust was brushed over the fingerprint for development. The adhesive swab was used to pull the latent fingerprint off the glass surface, similar to collection of a forensic tape pull. In addition to the latent fingerprint, a full set of ink-rolled exemplar fingerprints were also captured from the same volunteer. The latent print on the adhesive swab was analyzed directly with IMS. All fingerprints including both the exemplar and the latent were then scanned to digital form using an FBI Appendix-F certified scanning station. All images were cropped of most white-space, and the latent fingerprints were inverted across the vertical axis to correct for inversion resulting from the lift-capture. The digital fingerprints were measured for relative quality using the NFIQ algorithm [2], processed through the MINDTCT minutiae detector [3] and the resulting minutiae templates were matched using the BOZORTH matcher [3] to verify that a match can be made between the latent and the matching exemplar finger. Preliminary results show that the fingerprint swabs were capable of producing an IMS response for the explosive, and the lifted prints had enough fingerprint detail to make a positive match using the algorithm, even after thermal desorption. This presentation will introduce this novel approach of combining trace contraband detection with biometrics for field applications. Having the ability to collect a latent print and heat it for chemical analysis while keeping the print intact could be extremely useful for law enforcement and military operations. It could potentially reduce the cost and delay of sending fingerprint samples to a lab for chemical analysis. Chemical analysis in the laboratory may also affect the ability to analyze the fingerprint for biometric purposes. This work is beneficial to the forensic community by offering a unique latent fingerprint collection method that is compatible with quick field-deployable chemical analysis techniques that are currently in

use around the globe.

Keywords

Latent fingerprint, IMS, trace detection

Author Bio

Jessica has been a research chemist at NIST since March 2005. Her research interests include optical microscopy analysis of micro-particles, explosives and narcotics trace detection, biotechnology, and inkjet printing technology. As a forensic toxicologist, she focuses on the forensic aspects of explosives and narcotics detection which include micro-particle analysis, trace residue collection efficiency, and optimal collection media. Current efforts include developing methods to combine biometric and chemical analysis of fingerprints.

3:00 – 3:20 Forensic Analysis of Illicit Drugs and Trace Explosives using Ambient Pressure Ionization-Mass Spectrometry (API-MS)

Authors:

Tim M. Brewer, Christopher Szakal, Jennifer Verkouteren, and Greg Gillen, National Institute of Standards and Technology, Surface and Microanalysis Science Division, 100 Bureau Drive, Bldg 217, Gaithersburg, MD 20899

Title

Forensic Analysis of Illicit Drugs and Trace Explosives using Ambient Pressure Ionization-Mass Spectrometry (API-MS)

Learning Objective

After attending this presentation, attendees will understand how ambient pressure mass spectrometry is aiding the forensic community for the rapid and accurate trace explosive and narcotics analysis.

Impact Statement

This presentation will impact the forensic community by serving as a key aspect in trace narcotics and explosive analysis.

Abstract

The detection of illicit drugs and trace explosives represents one of the most significant challenges for law enforcement and forensic communities. Of particular interest to the forensic analyst is the ability to rapidly identify suspected illicit drug materials and explosives residues in their native state (powder, tablet or liquid form), under atmospheric conditions and with a high level of specificity and sensitivity. Ambient pressure ionization techniques such as atmospheric pressure glow discharge (APGD), low temperature plasma (LTP), and desorption electrospray ionization (DESI) can effectively desorb and ionize materials from most sample surfaces, including human skin, liquids and gas matrices under ambient conditions. Here, a series of ambient pressure ionization techniques coupled with mass spectrometry are explored and compared for the forensic analysis of a series of illicit drugs, over-the-counter pharmaceuticals, and trace explosives. Characteristic mass spectra from each ambient pressure ionization technique are used for the comparison. These results highlight the API-MS ability to

rapidly detect multiple species simultaneously in ambient pressure without prior sample preparation and chromatographic separation.

Keywords

Naroctics, explosive, detection

Author Bio

Tim M. Brewer received his PhD in analytical chemistry from Clemson University in 2007. In 2007 he was awarded a NRC Postdoc position working on trace explosive analysis. Currently he is an employee of NIST focusing on ambient pressure analysis of explosive and narcotics.

3:20 – 3:40 Improvements in Trace Involatile Vapor Quantitative Analysis

Authors:

Thomas J. Bruno and Tara M. Lovestead

Title

Improvements in Trace, Involatile Vapor Quantitative Analysis

Learning Objective

After attending this presentation, attendees will understand the basic principles of PLOT-cyroadsorption in vapor or head space analysis, and be able to select and design applications in criminalistics.

Impact Statement

This presentation will impact the forensic science community by increasing familiarity with a sensitive and quantitative head space sampling method that outperforms many current techniques.

Abstract

As much as any other analytical tool, criminalists routinely depend upon the analysis of vapors present above a crime scene artifact. Typically, the vapor analysis is done to gain an understanding of the chemical character of the artifact itself (the headspace of a substrate is examined to understand the condensed phase). While considerable progress has been made in this area (such as the development of solid phase microextraction, SPME), problems persist with sensitivity and especially with obtaining quantitative measurements. We have significantly improved the quantitative analysis of trace vapors in forensics by our introduction of PLOT-cyroadsorption, a technique that has lowered the analytical limit of trace vapor analysis while preserving low uncertainty quantitative measurements. Indeed, the results obtained by PLOT-cryoadsorption are of sufficiently low uncertainty to be correlated with the van't Hoff equation, and thus be made predictive. Moreover, the metrology is applicable to low volatility solutes, hitherto impossible by other methods. We first developed PLOT-cryoadsorption to assist the Department of Homeland Security with explosive vapor analysis. In this respect, we were able to quantitatively measure (as a function of temperature) the vapors arising from real explosives. This included taggents, plasticizers and crystallization solvents. Since then, we have applied the method to the detection of food adulteration (spoiled poultry and the detection of histamine in shrimp in collaboration with the FDA), the detection of hazardous chemical spills on soil, and the detection of accelerants in arson fire debris. We have also applied it to the detection of

illegally buried cadavers, and in an exciting development, a British adventure film company, Tigress Productions, wants to use the method to find the gravesite of Robert F. Scott, the British naval officer and explorer. He and members of his party were buried in a glacier in the Antarctic, and the documentary is to commemorate the 100th anniversary of his burial. In this presentation, we will cover the method in detail, and describe the numerous applications (mentioned above) of PLOT-cryo in forensic science. After attending this presentation, attendees will be able to select applications that might be appropriate for PLOT-cryoadsorption, and then to select the appropriate combination of sorbent phase, solvent, collection temperature, desorption temperature and collection time.

Keywords

headspace analysis, PLOT-cryoadsorption

Author Bio

Thomas J. Bruno, Ph.D., is a group leader in the Thermphysicial Properties Division at NIST, Boulder, Colorado. He received his B.S. in chemistry from Polytechnic Institute of Brooklyn, and his M.S. and Ph.D. in physical chemistry from Georgetown University. He has published 220 research papers, 7 books, and has been awarded 7 patents. He is associate editor of Handbook of Chemistry and Physics, (for analytical chemistry). He was awarded the Department of Commerce Bronze Medal and the Department of Commerce Silver Medal. He was Distinguished Finalist, Governor's Award for High Impact Research, 2011.

3:40 – 4:00 Unified Organic, Inorganic, and Morphological Analysis of Forensic Samples

Authors:

W. B. Doriese*, PhD, University of Colorado and NIST, Boulder CO, 80305 J. N. Ullom, PhD, NIST, Boulder CO, 80305 T. Jach, PhD, NIST, Gaithersburg MD, 20899 R. Cantor, PhD, STAR Cryoelectronics, Santa Fe NM, 87508

Title

Unified Organic, Inorganic, and Morphological Analysis of Forensic Samples

Learning Objective

This presentation will serve as an introduction to the use of very high resolution X-ray spectroscopy for the analysis of forensic samples.

Impact Statement

NIST-developed X-ray sensors coupled to widely-used scanning electron microscopes (SEMs) can provide elemental and chemical composition information on inorganic and organic material. The extension of SEM analysis to the chemistry of organics and other low-Z materials is novel.

Abstract

Scanning electron microscopes are widely used in criminal forensics to determine both sample morphology and composition. Composition is presently determined by X-ray fluorescence spectroscopy; the measurement of element-specific X-ray energies. In this presentation, we discuss the application of a new generation of X-ray sensors based on superconducting microcalorimeters. These X-ray sensors already provide roughly 50 times better energy resolution than conventional energy-dispersive X-ray detectors. We describe how microcalorimeters can resolve all elemental line overlaps, a capability relevant for the analysis

of metallurgical samples. We also describe how near-term improvements in sensor resolution may be able to provide chemical information on both inorganic and organic compounds such as explosives residue, drugs, and counterfeit medicine. The novel combination of morphological, inorganic, and organic analysis in a single tool will advance analysis speed and convenience. We present measured microcalorimeter X-ray spectra from metallurgical samples and explosive compounds. We also present measured reference spectra of the explosive materials TNT, RDX, and ammonium nitrate demonstrating that they possess identifying spectral features. We describe efforts to reproduce the reference spectra using theoretical calculations based on orbital bonding models. Finally, we describe maturing efforts to commercialize microcalorimeter technology, a necessary step for its widespread application in criminal forensics.

Keywords

rapid chemical analysis

Author Bio

Dr. Doriese has worked on sensor development at NIST for over 10 years. His research interests include synchrotron science, X-ray materials analysis, and high-speed readout electronics.

SELECTED POSTER: Ethanol in Water Standard Reference Materials to Support Forensic Testing

Author:
Michele M. Schantz, Analytical Chemistry Division, NIST, Gaithersburg, MD 20899

Abstract

Accurate calibration of instrumentation is critical in areas of forensic testing where quantitative analysis directly affects criminal prosecutions, as is the case with the determination of ethanol in blood and breath. Blood- and breath-alcohol testing can be imposed on individuals operating private vehicles such as cars, boats, or snowmobiles, or operators of commercial vehicles like trucks, planes, and ships. The various levels of blood-alcohol that determine whether these operators are considered legally impaired vary depending on the circumstances, state, and even month in which the testing is occurring. As a result, practitioners in the field of alcohol testing have a need for reliable and stable standards at several concentrations. Most blood alcohol levels in driving under the influence (DUI) cases fall in the range of 0.1% to 0.3% (the average blood alcohol for a DUI traffic stop is 0.16 % to 0.17%). By providing SRMs with concentration levels set to legally relevant points, the accuracy of blood- and breath-alcohol testing will be improved. Two ethanol in water SRMs, SRM 1828b and SRM 1847, with six and four concentrations, respectively, are available. The concentration levels in SRM 1828b, Ethanol-Water Solutions (Blood-Alcohol Testing: Six Levels), have been tailored to legally relevant points, specifically 0.02% and 0.04% for “zero tolerance” and occupational alcohol testing, 0.08% and 0.1% for state drunk driving laws, and 0.2% and 0.3% for an average and high level for blood alcohol measurements. In addition, three concentration levels of ethanol in water (2%, 6%, and 25%) have been prepared as SRM 1847, Ethanol-Water Solutions (Breath-Alcohol Testing: Three Levels), for use as reference solutions for breath-alcohol instruments. Since some laboratories calibrate at particular concentration levels, the 10 solutions are also available as individual SRMs.

SELECTED POSTER: Electrostatic Charge Measurements for Wipe Sampling: Surfaces and Particles

Authors:

Robert Fletcher,* Greg Gillen and James Kusmerick National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899 robert.fletcher@nist.gov

Title

Electrostatic Charge Measurements for Wipe Sampling: Surfaces and Particles

Learning Objective

This presentation will present methods of measuring relative charge domains on surfaces and particles

Impact Statement

This study may potentially show the influence of electrostatic charge on particle collection efficiencies by wipe sampling

Abstract

What is the effect of electrical charging on swipe collection? Swipe sampling to collect particulate reside is key to trace detection for explosives and drugs. The effectiveness of swipe collection may be influenced by electrical charge that exists on the particles, the swipe material and the substrate where the particles may reside. Charging arises because swipe sampling entails contact of dissimilar material surfaces resulting in triboelectric charging. We report on measurements using a NIST-constructed electrostatic microprobe that has the lateral spatial resolution of approximately 1000 μm. We have found that certain swipes charge significantly while cotton/muslin does not. Determining the influence of charge on particle collection is not entirely straightforward. The substrate and the swipe may contain charge of the same or opposite polarity and differing magnitude. Additionally, the particles may be charged. Measurements of particle charge on substrates using the microprobe have been challenging. In some cases the charged particles can be detected. We have made measurements using a commercial aerosol electrometer (AE). The AE determines a current produced for a flowing steam of charged airborne particles. Using this method, we can determine charged particles or ions liberated from the commonly employed swiping materials. Measurements are underway using a Kelvin probe to determine relative charge levels of particles residing on selected dielectric surfaces.

Keywords

electrostatic charge, particles,

Author Bio

The author has been a researcher at the NIST for over 30 years with his primary interest in physical and chemical characterization of particles.

SELECTED POSTER: Surrogate Controls to Enable Confidence in Field Measurements

Authors:

Lindsay Vang*, Jayne Morrow, Nathan Olson, Marc Salit, Zvi Kelman, Autumn Downey, Biochemical Science Division, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899

Title

Surrogate Controls to Enable Confidence in Field Measurements

Learning Objective

This poster will demonstrate the value a surrogate control material can have building confidence in field assessments related to potential biothreat incidences. The design, potential uses and applications of such a product will be explained.

Impact Statement

This work will impact the forensic community by increasing confidence in responses to suspected biothreat incidences. Having a material that can show user proficiency as well as aid in field demonstrations will help bridge the gap between a field assessment and response.

Abstract

The National Institute of Standards and Technology is designing a framework to assess technical performance of field systems used to detect and identify biothreat agents based on nucleic acid signatures. This framework includes an experimental design as well as surrogate controls that will enable confidence in measurements from field detection tools in the hands of the user by providing quantitative, objective measurements that can be repeated and compared at a lab and field level. To evaluate this design, NIST-generated DNA sequences were used as targets in serial dilutions to monitor the effect of inhibitors and background powders on qPCR assays. NIST ERCC sequences were designed to have minimal homology with any organism in the database (the sequences were generated randomly or from extremophiles). This makes them an ideal measurement control because the user can be confident that near-neighbors or environmental backgrounds are not generating positive reads from unknown samples. Yeast, a non-threat host, was chosen as a carrier for the surrogate controls because it can be used safely and routinely by any user. Yeast is also an attractive surrogate control material because of its tough cell wall and ability to sporulate, both characteristics that emulate the Bacillus anthracis threat agent. The homologous recombination of ERCC sequences into non-coding regions of the yeast genome will produce one unique target per yeast cell for nucleic acid detection. These targets can be easily counted under a microscope to produce quantitative measurements that will verify whether measurement tools are functional and capable of measuring threat targets. In the case where a material is deemed a biothreat, it is important to have confidence in the measurements being made by those handling the response. Such a product has many implications for the microbial forensic community. The use of a surrogate control material shows the users ability to gather instrument responses in the field under diverse environmental conditions as well as demonstrating the technology is functioning in the hands of the user. As a result, First Responders and the labs they interface with may have more confidence in the measurements taken in the hands of the user in the field. Finally, these materials can be used in training exercises to trigger a “field detect” as well as challenge the process from collection to detection. By increasing the confidence in responses to biothreat incidences, such a material can be

instrumental in enabling more rapid forensic investigations.

Keywords

Confidence, Biothreat, Detection

Author Bio

Lindsay Vang is a technician in the Biochemical Science Division at the National Institute of Standards and Technology. Her work focuses on designing a framework for assessing the technical performance of field-deployed systems used in biothreat responses, including contol material and assay design. Prior to NIST, Lindsay received a Masters of Science in Biotechnology from Georgetown University as well as a Bachelors of Science in Biochemistry and Molecular Biology from the University of Richmond.

SELECTED POSTER: Analysis of the chemical composition of single particles by confocal Raman microscopy

Authors:

Chris A. Michaels, Ph.D.*, Surface and Microanalysis Science Division, Material Measurement Laboratory, NIST, Gaithersburg, MD 20899.

Title

Analysis of the chemical composition of single particles by confocal Raman microscopy.

Learning Objective

This paper will present the basic principles of Raman microscopy, the instrumental design, examples of the application of this technique in the chemical analysis of single particles along with a discussion of the merits and limitations of this approach.

Impact Statement

The presentation will broaden the awareness of the utility of confocal Raman microscopy within the forensics community.

Abstract

Confocal Raman microscopy is a powerful technique for determining the chemical composition of microscopic particles based on their vibrational spectra. This paper will include an examination of specific aspects of a custom instrument design that facilitates analyses of particles. Several specific examples of the application of this technique to the chemical analysis of different classes of particles of relevance to the homeland security/forensics community will also be presented. A strategy for performing Raman analysis on particles whose atomic composition has been determined by X-ray spectrometry will be reviewed. Finally, a broad survey of the characteristics of this analysis method that make it attractive to forensic applications, along with potential pitfalls, will be discussed.

Keywords

Raman, Microscopy

Author Bio

Chris A. Michaels is a Research Chemist in the Surface and Microanalysis Science Division of the Material Measurement Laboratory at NIST. He received a B.A. with Distinction from

Swarthmore College in 1992 and a Ph.D. from Columbia University in 1997 working under the supervision of G.W. Flynn. He then joined NIST as an NRC postdoctoral fellow in the group of R.R. Cavanagh. His current research efforts are focused on the development and application of spectroscopic imaging techniques for high spatial resolution chemical microscopy. He has received the Samuel Wesley Stratton award and the Department of Commerce Bronze Medal.

SELECTED POSTER: Using High Performance Liquid Chromatography for the Quantification of Explosives and Narcotics Standard Materials

Authors:

Tim M. Brewer, Ashley Newton, Anne Kenslea, Jennifer Verkouteren, Leonard Demoranville, Robert Fletcher and Matthew Staymates National Institute of Standards and Technology, Surface and Microanalysis Science Division, 100 Bureau Drive, Bldg 217, Gaithersburg, MD 20899

Title

Using High Performance Liquid Chromatography for the Quantification of Explosives and Narcotics Standard Materials

Learning Objective

After attending this presentation, attendees will understand how high performance liquid chromatography is aiding the forensic community for the analysis of trace explosive and narcotics standards materials.

Impact Statement

This presentation will impact the forensic community by serving as a key aspect in trace narcotics and explosive analysis.

Abstract

At the National Institute of Standards and Technology (NIST), microspheres containing trace amounts of high explosives such as trinitrotoluene (TNT) were prepared by an oil/water emulsion process using a precision particle fabrication nozzle. Precisely controlled microdrops of a known amount of PLGA/TNT in dichloromethane are injected into a water bath containing a 1 % polyvinyl alcohol solution where the microspheres are allowed to cure. The analysis of the explosives encapsulated microspheres by ion mobility spectrometry showed a lower than expected response from calculated values of TNT. Presented here is the quantification of explosives in the polymer microspheres by high performance liquid chromatography with UV/Visible detection (HPLC-UV/Vis). A size exclusion separation was employed to quantify the amount of explosive encapsulated in cured microspheres. Results indicate that there is a 30 % to upwards of 50 % loss of TNT explosive from the polymer microspheres. Additionally a method was developed to extract nanogram levels of explosive and narcotic compounds from Teflon and Teflon-coated substrates. Extraction efficiency and quantification was also determined by using HPLC/UV-Vis. Various extraction methods were evaluated for extraction of explosive and narcotics that maximize extraction efficiency while maintaining detection efficiency of inkjet printed materials.

Keywords

Naroctics, explosive, detection

Author Bio

Tim M. Brewer received his PhD in analytical chemistry from Clemson University in 2007. In 2007 he was awarded a NRC Postdoc position working on trace explosive analysis in the Surface and Microanalysis Science division. Currently at NIST he is focusing on ambient pressure analysis of explosive and narcotics.

SELECTED POSTER: Forensic Analysis Methodology and Database of Statistically Combined HME Thermal, Mass, and Spectral Signatures

Authors:

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Title

Forensic Analysis Methodology and Database of Statistically Combined HME Thermal, Mass, and Spectral Signatures

Learning Objective

Attendees will be made aware of a new methodology to be developed to provide reliable forensic information on HMEs, which is critical for (a) identifying the origin of the explosive materials and precursors, and (b) determining HME formulation and synthesis procedures.

Impact Statement

This presentation will provide information on improving the confidence level in forensics analysis of HME materials, which will enable law enforcement and military personnel to disrupt and discourage HME manufacturing, and provide protocols for safe HME disposal.

Abstract

Homemade explosives (HME) are used increasingly by extremists and terrorists due to the widespread availability and easy accessibility of the precursors. The non-standard (i.e., improvised) nature of HME mixture chemical composition and formulation/synthesis procedures presents a formidable challenge for forensic processing and analysis. The forensic examination of the pre- and post-blast physical evidence also lacks specificity for HME identification. The availability of reliable data characterizing HMEs is essential for the forensic science community to (a) identify the origin of explosive materials and precursors, and (b) determine HME formulation/synthesis procedures. Also, reliable data can help law enforcement and military disrupt or discourage the manufacturing of HME chemical formulations, and provide protocols for safe HME disposal. The authors will describe a new forensic analysis methodology and database tool of statistically combined thermal, mass, and optical-spectral signatures for HME chemical identification under different environmental conditions. Statistically combined signatures, obtained from different independent measurement techniques, will improve the confidence level for HME identification and will reduce the forensic processing time. It is expected that this approach will enable development of a standardized methodology and data

format for populating the signature database, as well as preparation of reference materials for use by the forensic community and possible conveyance of supplemental information to the database. Thermal-signature methodology: A state-of-the-art, rapid laser heating technique, referred to as the laser-driven thermal reactor (LDTR), is being developed to provide temporally resolved thermal signatures (thermograms) of multiphase, multicomponent energetic materials. The technique also has the capability to collect chemical reaction products for spectroscopic chemical analysis. The technique has been used in the past to provide in-situ quantitative measurements of various relevant thermophysical and chemical properties, including rates of heat release and chemical kinetics, total heat value, specific heat/energy release, threshold temperature for thermal explosion, and chemical reaction product identification. The NIST LDTR has also demonstrated improved measurement sensitivity over commonly used differential scanning calorimetry for detecting in-situ HME thermophysical and chemical behavior. To this end, a thermal-/chemical-signature database is being developed for identification of pre-selected HME precursor materials. Mass-signature methodology: The reliable identification of volatile compounds associated with HMEs is routinely carried out by gas chromatography/mass spectrometry, often involving a portable instrument. This method identifies compounds by matching their reference spectra and retention properties to reference data held in a library. These identifications are only as reliable as the information contained in these libraries, including the realistic assessment of the false positive potential of each HME target compound. A library is to be developed, based on the widely used NIST/EPA/NIH Mass Spectral Library of over 200,000 compounds. A fully evaluated library of spectra will be developed of known HME target compounds, including the re-measurement of spectra and retention properties of uncertain quality. It will also entail the creation of a collection of plausible false positive identifications, made by searching the NIST comprehensive library with actual HME-related spectra, including a manual evaluation of results. Optical-spectral signature methodology: Optical-spectral signatures, such as infrared signatures, are also an important component of HME forensic analysis, since they provide complementary information to mass spectral signatures and additional key information for identifying the chemical composition, HME sources, mixture types, and particle size classes. In addition, spectral signatures can assist in identifying HME formulation procedures, e.g., use of grinding, additives, and mixing of components. Spectral signatures also provide operational benefits for remote and stand-off detection, which is important for field applications. Another example is diffuse reflectance which measures the reflected light from the samples and provides physical surface information about the HME material. Validated infrared signature reference libraries are to be developed for HME detection and identification. Combined-data methodology: A statistical/probability methodology will be developed to combine the three sets of signatures into an accessible database, which specifies confidence levels associated with the proper identification of a selected HME chemical. A variety of different mathematical approaches are being considered, including the Dempster-Shafer theory and Rule-Based Data Fusion methods. Ultimately, the thermal, mass, and spectral signatures will be statistically combined and correlated to pre-identified HME precursors, and used to establish a database with specified confidence levels.

Keywords

HME, Thermal-mass-spectral signatures -

Author Bio

Ashot Nazarian has expertise in defining capability gaps for counter-IED solutions including

homemade explosives and is the inventor of the LDTR technique. Cary Presser (thermal signatures), Steve Stein (mass signatures), and Pamela Chu (spectral signatures) work at NIST and have expertise in using the LDTR, GC/MS, and FTIR, respectively. Gary Citrenbaum has expertise in data fusion methodologies.

SELECTED POSTER: Identifying potential molecular chronometers in fingerprints using C60+ Secondary Ion Mass Spectrometry

Authors:

Edward Sisco, BS*; University of Maryland, Department of Chemistry, College Park, MD 20742 Leonard Demoranville, PhD, Greg Gillen, PhD, and Jessica Staymates, MFS, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899

Title

Identifying potential molecular chronometers in fingerprints using C60+ Secondary Ion Mass Spectrometry

Learning Objective

This presentation will provide the forensic science community with an evaluation of a new technique to analyze fingerprints. C60+ SIMS involves the bombardment of a focused ion beam on a sample to generate secondary ions characteristic of the chemical composition of the sample. The benefit of C60+ SIMS over the traditional techniques is that C60+ SIMS could provide spatially resolved analysis and also has the potential to probe the composition of a fingerprint as a function of depth. With respect to mass spectrometry techniques, the C60+ is a soft ionization technique which allows for a less fragmented molecular profile of the sample. Using this technique also does not completely destroy the fingerprint, making it possible for comparisons to be made after being analyzed by C60+ SIMS.

Impact Statement

After attending this presentation the audience will be familiar with some of the possible uses of Dynamic C60+ Secondary Ion Mass Spectrometry (SIMS) for the chemical analysis of fingerprints. The potential abilities of this technique to image a fingerprint and monitor the changes in composition with time will be emphasized.

Abstract

Fingerprint development and imaging is a well-established and well researched area in forensic science. However, the ability to both image and chemically analyze a fingerprint has been less commonly studied. The research focuses on the changes in the composition of fingerprints with time when exposed to a variety of environmental conditions (i.e. heat, humidity, and ultraviolet radiation). By doing so, potential molecular chronometers can be identified in an attempt to determine a timeframe of deposition. This could be useful evidentiary information as it may allow investigators to place a suspect at a scene within a certain timeframe or, similarly, rule out the presence of a suspect during the time of a crime based on the timeframe. To better understand changes which occur due to environmental factors, a chemically relevant artificial fingerprint material was developed to mimic both the eccrine and sebaceous secretions found in a normal fingerprint. The artificial fingerprint material provides more consistent and repeatable results than using actual fingerprints. In this study synthetic fingerprint material was either drop coated or printed, using a high viscosity polymer printer, onto silicon disks which

were analyzed using the SIMS technique. A control disk was studied simultaneously with all environmentally exposed disks to note any changes in sample due to the vacuum. Experimentally exposed disks were subjected to a variety of conditions and mass spectra of the disks were collected at various time points throughout the study. The spectra were then compared to determine what, if any, chemical changes occurred which could be used as molecular chronometers for measuring time since deposition. Once completed using the artificial fingerprint material, the studies were replicated with actual fingerprints to see if the same chronometers were found to produce similar results. The imaging capabilities of actual fingerprints using C60+ SIMS were also studied.

Keywords

Fingerprints, C60+SIMS, ChemicalAnalysis

Author Bio

Ed Sisco is currently a graduate student in the Chemistry program at the University of Maryland, College Park. He is doing research with Dr. Greg Gillen's group at NIST which focuses on potential methods of age dating fingerprints. Additional research projects include working with the U.S. Army Criminal Investigations Laboratory on trace explosives detection.

SELECTED POSTER: Optimization of Negative Chemical Ionization Mass Spectrometry for Explosives for Two Gas Chromatographic/Mass Spectrometric Instruments from Different Manufacturers.

Bruce A, Benner, Jr. and Marcela Najarro, NIST, 100 Bureau Drive Stop 8392, Gaithersburg, MD 20899

Introduction: Refining explosives measurements has been a priority for both homeland security and environmental researchers. Gas chromatography with negative chemical ionization mass spectrometry (GC/NCI MS) is a selective and sensitive technique for measuring explosives. Unlike electron impact ionization MS, where an analyte's mass spectrum is similar between instruments, NCI mass spectra can differ significantly from different instruments due to subtleties in ionization caused by experimental parameters and instrument designs. To illuminate differences in NCI mass spectra of explosives, we optimized temperature settings and

reagent gas flow rates for two GC/NCI MS instruments from different manufacturers. This presentation will summarize results of these optimizations concerning overall sensitivities of seventeen energetic species, and compare mass spectra generated by the two systems.

Method: Energetic mixtures composed of diluted commercial standards were used in the optimization of the GC/NCI MS instruments. Explosives were measured using two commercial bench-top GC/MS systems equipped with 6 m x 0.25 mm HT-5 and 15 m x 0.25 mm Rtx-5ms (both 0.1 µm phase) capillary columns operated at 6 mL/min helium flow, and heated from 80 ºC to 200 ºC at 30 ºC/min and 45 ºC/min. Mass spectrometers were run in NCI modes scanning from 45 mass/charge (*m/z)* to 250 *m/z* or 350 *m/z* with methane (reagent) flows from 0.25 mL/min to 5 mL/min. Temperature zones of the mass spectrometers were varied from 75 ºC to 250 ºC.

Preliminary Data: Increasing the source temperatures of the mass spectrometers increased the relative abundances of the smaller *m/z* ions in the mass spectra of most energetic compounds. Lesser effects on the mass spectra were observed while varying the temperatures of the analyzers. Increasing the flow rates of the reagent gas (methane) generally increased the responses of the individual energetic compounds. Methane in NCI MS is a collision gas that reduces the energies of the electrons emitted by the filaments to the level of thermal electrons. These thermal electrons can then be captured by the explosive compounds, resulting in negatively charged ions. As the methane gas flows were varied, and thus the average energy of the source electrons, we did not observe changes in the relative abundances of ion fragments in the mass spectra of the energetic compounds. This result was somewhat surprising, since additional electronic energies imparted to the molecular ion and fragments could conceivably shift relative abundances toward lower m/z fragments. Additionally, we observed no detectable negative ion formation below 0.5 mL/min methane flow (1.2×10^{-4} torr, analyzer pressure) and no significant increase in background at higher reagent gas flows- a significant sensitivity advantage provided by NCI MS. Mass spectra for most of the energetic compounds were similar between the two instruments except for 1,3,5,7-tetranitro-1,3,5,7-tetraazacyclooctane (HMX), for which the mass spectrum of one instrument was shifted to the lower *m/z* ions, and to higher *m/z* ions for the other instrument.

Novel Aspect: Comparison of NCI mass spectra of explosives generated by two commercially available bench-top GC/MS instruments from different manufacturers.

November 30, 2012 – Day Three

Computer & Multimedia Forensics and Fingerprints & Biometrics Sessions – Green Auditorium

Computer and Multimedia Forensics

9:20 – 9:40 National Software Reference Library Diskprint Methods and Tools & Creation and Measurement of Baseline Machines for NSRL Diskprint Research

Authors:

Mary Laamanen, NIST, 100 Bureau Drive, Gaithersburg, MD 20899; Alison Benjamin, NIST, 100 Bureau Drive, Gaithersburg, MD 20899; John Tebbutt NIST, 100 Bureau Drive, Gaithersburg, MD 20899; Douglas White, NIST, 100 Bureau Drive, Gaithersburg, MD 20899;

Title

National Software Reference Library Diskprint Methods and Tools & Creation and Measurement of Baseline Machines for NSRL Diskprint Research

Learning Objective

The presentation will inform attendees as to the methods used at NIST to capture application diskprints to be used in forensic analysis of software applications and methods used at NIST to create baseline computer reference systems on which application lifetime effects can then be measured.

Impact Statement

This presentation will impact the computer forensic and other communities interested in the lifecycle effects of computer software by making transparent, repeatable and verifiable the methods used by the NSRL in the installation, use and deletion of application software on various operating systems and in the creation of baseline reference virtual machine systems for use in the measurement of application lifecycle effects.

Abstract

This presentation details the methods used in the installation, use and deletion of application software on virtual machines used by the NSRL for software lifecycle research. The NSRL RDS and its associated database contain file-based metadata about software derived from software installation media. While this metadata is generally useful in identifying software installed on a computer, it tells only part of the story. As the sophistication of the forensic process advances, demand continues to burgeon for a more complete description of the effects software has on a system. The NSRL is responding to this demand by augmenting the file metadata published in the RDS with data that catalog these effects. This is accomplished by modifying known systems under controlled conditions and recording the effects using virtual machine installations. Baseline systems exist with characteristics that have been measured, to support the collection of data on the changes wrought by software installations. The

methodology by which the NSRL creates the application diskprints in a controlled process to identify critical capture points is detailed here for the purpose of transparency and repeatability.

This presentation also details the methods used in the creation of the reference virtual machines used by the NSRL for software lifecycle research. The NSRL RDS and its associated database contain file-based metadata about software derived from software installation media. While this metadata is generally useful in identifying software installed on a computer, it tells only part of the story. As the sophistication of the forensic process advances, demand continues to burgeon for a more complete description of the effects software has on a system. The NSRL is responding to this demand by augmenting the file metadata published in the RDS with data that catalog these effects. This is accomplished by modifying known systems under controlled conditions and recording the effects using virtual machine installations. In order to collect data on the changes wrought by software installations, baseline systems must exist and their characteristics be measured. The methodology by which the NSRL creates the baseline systems, from choice of virtual machine technology through virtual hardware settings to operating system installation and configuration, is detailed here for the purpose of transparency and repeatability.

Keywords

software application diskprint

Author Bio

Mary Laamanen: *Biography not submitted*

Alison Benjamin is a sophomore student at Salisbury University, whose primary responisibilty is the capture of diskprints. Mary Laamanen has been a Computer Scientist for 24 years at NIST. She has an interest in computer forensics, XML, databases, and tool testing. Douglas White has been a Computer Scientist for 25 years at NIST. He is the project leader for the NSRL, and has been involved in computer forensics for 12 years.

John Tebutt has worked in digital forensics for over ten years, concentrating on the provision of standardized data to domestic and international law enforcement agencies. Prior to that his focus was on the development of open standards for data interchange, including working on the W3C XML Schema Working Group and with ISO/CCITT on X.500/LDAP. He has also worked in automated hypertext linking and text retrieval/search technologies. John Joined NIST in 1987.

9:40 – 10:00 File Identification in iOS

Authors:

Michael Ogata, NIST, 100 Bureau Drive, Gaithersburg, MD 20899

Title

File Identification in iOS

Learning Objective

An observer should leave this presentation with a basic understand of the contents of the NSRL and how the NSRL methodology for harvesting files from applications can be applied to iOS

devices. An observer should also have a cursory understand of the methods for harvesting files from an iOS mobile device and how the architecture of iOS applications can be leveraged to glen information about those applications capabilities.

Impact Statement

This presentation will impact the forensic community by demonstrating the NSRL method for file identification is applicable to the iOS platform. It also opens up the possibility of describing a phone's capabilities by describing the capabilities of the applications installed on that phone.

Abstract

The National Software Reference Library (NSRL) maintains a dataset of 26 million unique file signatures harvested from computer application. Forensic investigators can use these signatures to both disambiguate potential evidentiary files from more benign files and identify content on a target computer. Smart phones have become ubiquitous in the cell phone ecosystem. These mobile computers can contain thousands of files that may be of interest to a forensic investigator. This presentation aims to demonstrate the effectiveness of the NSRL method of file identification as applied to the iOS mobile device environment and to show potential methods for mobile application classification based on this file identification. iOS applications can contain may features knowledge of which can be of potential benefit to investigators. These features include functionality such as: access to the device's location awareness framework, access to the device's address book, the use of SQLite databases, and so on.

Keywords

Hash, Mobile, Identification

Author Bio

Michael Ogata is a computer scientist at the National Institute of Standards and Technology (NIST). Michael holds a B.S in computer Science from the University of Maryland Baltimore County. He has been working with the National Software Reference Library project at NIST for eight years.

10:00 – 10:20 Computer Forensic Tool Testing (CFTT) at NIST

Authors:

James R. Lyle

Title

Computer Forensic Tool Testing (CFTT) at NIST

Learning Objective

After attending the presentation, attendees will be made aware of some of the strategies used by

the Computer Forensics Tool Testing (CFTT) project at the National Institute of Standards and Technology (NIST) for testing computer forensic tools used in the acquisition of digital evidence. One surprising result is that for some testing situations, best testing practice is different from best forensic practice. Practitioners can then apply the strategies in their own testing activities.

Impact Statement

The presentation will impact the forensic community by increasing awareness in the community of the impact tool test strategies have on the ability of tool testing to reveal anomalies in tool behavior.

Abstract

The Computer Forensics Tool Testing (CFTT) project at the National Institute of Standards and Technology develops methodologies for testing computer forensic tools. We have applied the developed test methodologies to several tools in the areas of disk imaging and write blocking. We are currently developing test strategies for testing storage erasing, deleted file recovery and string searching. A test strategy should cover all tool features and also give the tool opportunities to fail in easily detectable ways. For example, good forensic practice is to start by writing zeros to any pieces of media that would be used in an examination of digital data. However, one common way for a tool to fail is to place information in the wrong location. If a block of zeros is transposed with another block of zeros the switch is undetectable. A better practice for media initialization during testing is to write unique content to each disk sector. This has the advantage that out of place data is easy to recognize. If the unique data also includes the original location of each sector then knowing the original location may be helpful in characterization of the tool behavior. Disk imaging involves acquiring an image of either a physical hard drive or a disk partition, also called a logical drive. A disk imaging tool functions by reading each sector from the drive to be examined and creating either an image file or a clone of the original on a similar device. An image file contains all information to exactly reconstitute the original hard drive. While an image file may be stored as a bit for bit copy of the original, it is usually compressed in some way to save space. Write Blocking is used to protect original digital data from modification during acquisition or preliminary inspection to determination relevance to an investigation. Storage erasing, as considered by CFTT, is for storage device reuse within an organization rather than for disposal or transfer to a destination outside the organization. This presentation examines selected test cases and test procedures used by the CFTT project to demonstrate the kinds of tool errors that can be revealed by each strategy.

Keywords

Forensic Software, Testing

Author Bio

Dr. Lyle wrote his first FORTRAN program in 1968 and has been programming ever since. He received a B.S. in Mathematics (1972) and an M.S. in Mathematics (1975) from East Tennessee State University; from the University of Maryland at College Park, Dr. Lyle received an M.S. (1982) and PhD (1984) in Computer Science. Before joining NIST full time in 1993, Dr. Lyle was a Faculty Associate at NIST and an Assistant Professor at the University of Maryland Baltimore County. Dr. Lyle's interests include Software Engineering & Digital Forensics. His interests within Digital Forensics include: • Requirements specification • Digital forensic tools

10:50 – 11:10 Mobile Device Tool Testing

Authors:

Richard Ayers

Title

Mobile Device Tool Testing

Learning Objective

After attending the presentation, attendees will be made aware of the importance of tool testing and gain an understanding of the mobile device tool testing process conducted within the Computer Forensics Tool Testing (CFTT) project.

Impact Statement

The CFTT project at the National Institute of Standards and Technology (NIST) produces specifications, test methods and test reports that provide a foundation for toolmakers to improve tools, users to make informed choices, and provide interested parties with an overview of any anomalies found. The presentation will provide an overview of the motivation behind testing mobile device forensic tools and the challenges faced by toolmakers and forensic examiners.

Abstract

CFTT has spent several years researching and testing forensic tools capable of acquiring data from the internal memory of mobile devices and Subscriber Identity Modules (SIMs). This presentation discusses all aspects of the testing process that are critical for producing a test report. The development of mobile device forensic tools and acquisition techniques continues to grow within the field of digital forensics. Mobile subscribers far out number personal computer owners and studies have shown an increase of mobile device personal data storage compared to personal computers. Today, four times the number of mobile subscribers exists compared to the owners of personal computers. Higher-end mobile devices present users with advanced features and capabilities similar to those of a personal computer. Mobile devices provide users with the ability to maintain contact information, upcoming appointments, day to day activities, and provide us with the ability to correspond with friends and family via text message, email, chat and social networking sites. Over time, mobile devices can accumulate a sizeable amount of information about their owner. Data acquired from these devices may be useful in criminal cases or civil disputes. As mobile device usage and sophistication continues to grow so does the need for tool validation. In order for acquired information to be admissible in a court of law, verification of a tools behavior and strict forensic acquisition methods are paramount. Potentially, one piece of data acquired from a mobile device may play a critical role in shedding light on an incident or possibly criminal activity. The need for rigorous testing conducted on a combination of forensic tools and specific families of mobile devices is critical for providing law enforcement and forensic examiners informative test results yielding known expectations of a tools behavior, capabilities and limitations. Over the past five years the CFTT project at NIST has tested numerous mobile device forensic tools capable of acquiring data from mobile devices operating over Global System for Mobile (GSM) communications and Code Division Multiple Access (CDMA) networks.

Keywords

Mobile_Device_Forensics, Digital, Testing

Author Bio

Mr. Rick Ayers is a computer scientist in the Information Technology Laboratory at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. Rick, a participant of the Cyber Corps program graduated from the University of Tulsa with a BS and MS in computer science. Current research focus is on mobile device forensics tools and proper acquisition techniques.

11:10 – 11:30 Developing a Forensic Image Examination Rating Scale

Author:
Charles Fenimore*, PhD, and Wo Chang, MS, Information Access Division, National Institute of Standards and Technology, Gaithersburg MD 20899-0894

Learning Objectives:
Attendees will understand the concept of rating the examination potential of still and motion imagery, the quality factors that are significant in completing image examination tasks, and the reliability of measurement models for estimating image examination potential.

Impact Statement:
The research on developing an Image Examination Rating Scale will impact the law enforcement forensics community by quantifying the reliability of forensic image interpretation for a given image and examination task. Two particular application areas are: (i) automated rating measurement of images will support fast image selection in screening of large collections; and (ii) quantifying the value of an image in the completion of a specific interpretation task will provide an objective measure of evidentiary value, reducing the potential for mischaracterizing image evidence.

One sentence statement of the paper's hypothesis/proposition:
The research hypothesis is that, in a collection of 60 forensics-related images, 10 or more images span the scale range (0 – 100) and are consistently rated (< 5.0) by image experts. We determine the goodness of fit of an image quality model based on measured image resolution, signal-to-noise and image blur. Taken together, such images define an engineering scale for forensic image examination.

Brief synopsis of methods:
Law enforcement forensic image examination (as defined by the Scientific Working Group on Image Technology, SWGIT) includes the interpretation of imagery to detect, differentiate or identify objects and people in finding evidence related to public safety. Interpretability is affected by the image quality, yet there is no measurement method for relating quality to image interpretation potential. This research adopts the methodology of the existing National Image Interpretability Rating Scale (NIIRS) used in the surveillance and intelligence community. The research presented here develops several (~10) reference images that span the range of quality

found in forensic imagery and that are consistently rated by image experts. A regression model is fitted to the quality ratings and is compared to the NIIRS quality model.
Forensic imagery "in the wild" is frequently captured with little or no control of lighting, pose and distance to the objects or persons. Because quality can vary in different regions, the forensic image rating scale uses localized measures of image quality factors. In addition, the expert image rating study uses several marker reference images in order to reduce the inter-rater variation. These modifications to the NIIRS methodology are made to reduce variation in the image ratings and in the measured image quality.

A summary of the results obtained:
Prior to the expert rating of imagery (as in 1), preliminary measurements of the reliability of the measured quality factors and the sensitivity of the candidate NIIRS image quality model were made. The image signal range is 0 – 255 (non-dimensional units)

- In the image collections available for the study, the range of resolutions, measured as the spacing of pixels projected onto the region of interest, ranges from ~ 1.65 – 1780 mm.
- measured image noise (, measured as sample standard deviation in flat portions of the imagery) ~ 2 (noise floor = 1/ √12 ~ 0.3).

A general statement of conclusion:
The development of a Forensic Image Examination Rating Scale and the validation of a semi-automated quality model would support reliability estimates in the quality rating of forensic images. Initial measurements of image quality for the evaluation collection indicate the desired quality range of the imagery is adequate to support a 9 or 10 level scale. The ranges in the image quality factors (resolution, blurring, and SNR) are adequate for the regression analysis. Initial informal viewing suggests there are many images for which the inter-rater standard uncertainty falls below the targeted value, ~ 5.0.
Future scale development research focuses on three main goals.
- develop many (~30) interpretation tasks that can be completed using the reference images developed in this study. Tasks for object detection/ differentiation/ identification are rated at the lowest quality level of the images that support task completion.
- validate the scale by rating an independent set of images using the developed tasks
- fit the quality factor data to the image ratings to develop a validated forensic image interpretability model.

Key words:
Image, Examination, Quality

11:30 – 11:50 Instance search, copy detection, and semantic indexing at TRECVID

Authors:

Paul Over

Title

Instance search, copy detection, and semantic indexing at TRECVID

Learning Objective

The presentation will summarize the successful efforts within NIST's TRECVID workshop series to promote development and scientific evaluation of technologies for three general large-scale video analysis/exploitation tasks of potential interest to the forensics community: 1) finding all instances of a particular person, object, or location, 2) detecting transformed copies of target video, and 3) extracting high-level audio-visual features/concepts. It will also highlight the need for use case information and test data relevant to forensic applications.

Impact Statement

Better tools for efficient, accurate instance search will enable/improve access and use of video archives, personal video, as well as crime-related video material. Reliable copy detection is needed on a vast scale to enforce help intellectual property rights uncover modified versions of illicit video material. Automatic high-level feature detectors can be fundamental to ad hoc search and in one case are being marketed to police in the Netherlands for detection of child abuse in images/videos on confiscated computers/DVDs/tapes. TRECVID has worked with various research communities to build infrastructure and run evaluations that promote research in these areas, among others.

Abstract

In the semantic indexing task, systems are given the textual definitions and training examples for over 300 concepts such as "female_person", "running", "old people", "explosion-fire", "hand", "car", etc. In 2011 a top fully automatic system returned on average 7 shots containing the desired concept in the top 10 shots it returned from a test collection of about 137000 shots. In 2011 copy detection systems were confronted with 11256 queries, 2/3 of which contained short video segments from a target collection. The queries were constructed by NIST starting from 201 base queries, which were subjected to random combinations of 1 of 8 video and 1 of 7 audio transformations (8 * 7 * 201 = 11256). Systems were asked to determine for each query, whether it contains material from the target collection and if so where the target segment started and ended in the query. On average, out of 134 copied videos, a top system could detect 126 with a false alarm rate of almost 0. In the instance search task, systems are given queries, each of which contains 3-5 images of an object, person, or location to be found in a large collection of video. In 2011, a top system returned on average 9 shots containing an instance of the desired item in the top 10 shots returned from an experimental test collection of about 21000 shots.

Keywords

video analytics, TRECVID

Author Bio

Paul Over, Ph. D., is a computer scientist at the US National Institute of Standards and Technology and founding project leader for the TREC Video Retrieval Evaluations (TRECVID) - an international effort since 2001 to promote open, metrics-based research in video retrieval and analysis systems, both interactive (human-in-the-loop) and fully automatic. Dr. Ian Soboroff is a computer scientist and manager of the Retrieval Group at the National Institute of Standards and Technology (NIST). His current research interests include building test collections for social media environments and nontraditional retrieval tasks.

Fingerprints & Biometrics

1:20 – 1:40 Overview of the NIST Evaluation of Latent Fingerprint Technologies (ELFT) Project

Authors:

Michael D. Indovina

Title

Overview of the NIST Evaluation of Latent Fingerprint Technologies (ELFT) Project

Learning Objective

This presentation will provide an overview of what NIST is doing in the area of automated latent fingerprint identification systems (AFIS). Topics of particular focus will be latent AFIS interoperability, "lights out" latent matching, workload reduction, and overall system performance evaluation.

Impact Statement

Through its open testing and analysis of commercial latent AFIS, the ELFT project provides critical data necessary to understanding and improving the interoperability, performance, and workflow of latent fingerprint operations.

Abstract

Since 2006, the NIST Evaluation of Latent Fingerprint Technologies (ELFT) project has conducted five evaluations of automated latent fingerprint identification systems (AFIS), with ten individual vendors of commercial AFIS systems voluntarily participating. ELFT is an interactive effort between NIST and latent AFIS community to improve accuracy, promote interoperability, and reduce reliance on human examiners. It is a large-scale open evaluation of automated latent fingerprint identification systems (AFIS) using automatic feature extraction and matching (AFEM) and standardized extended feature (EFS) hand-marked by human experts. Through its open testing and analysis of commercial latent AFIS, the ELFT project provides critical data necessary to understanding and improving the interoperability, performance, and workflow of latent fingerprint operations.

Keywords

biometrics, latent, fingerprints

Author Bio

Mr. Indovina has 23 years of experience in algorithm development, cryptography, smart card design, and performance testing. For the past 10 years he's been focused on the evaluation of fingerprint biometric systems, during which time he designed the software interfaces, drivers, and acceptance testing procedures for the majority of NIST's biometric SDK-based tests. He is currently project lead for the Evaluation of Latent Fingerprint Technologies (ELFT), which is investigating the performance characteristics of latent fingerprint identifications systems. Since 2006 the ELFT project has conducted five open evaluations including eleven industrial vendors of automated fingerprint identification systems (AFIS).

1:40 – 2:00 Fingerprint Quality – Elham Tabassi, Information Access Division, ITL

Abstracts not submitted

2:00 – 2:20 Biometrics & Forensics: The role of standards in data exchange

Authors:
Brad Wing * Biometrics Standards Coordinator NIST 100 Bureau Drive, Mail Stop 8940 Gaithersburg, Md. 20899

Title

Biometrics & Forensics: The role of standards in data exchange

Learning Objective

Understand the role of standards in facilitating data interoperability for law enforcement, military, intelligence, disaster recovery and homeland security operations around the world. Know what has been recently adopted into the ANSI/NIST-ITL standard to support forensics and what is in the works, as well as how to participate in the process.

Impact Statement

The ANSI/NIST-ITL standard is used throughout the world to exchange biometric and forensic data and associated information. It is the basis for the FBI's IAFIS fingerprint data interface, the Department of Homeland Security's IDENT system, the US Department of Defense biometrics data system, INTERPOL's fingerprint system, the European Union's visa identification system and much more.

Abstract

The audience will understand how the ANSI/NIST-ITL standard "Data Format for the Interchange of Fingerprint, Facial and Other Biometric Information" is used by law enforcement and disaster victim identification. An illustrative case involving an unidentified deceased individual will be presented, including the use of fingerprints, palm prints, plantar prints, DNA, facial images, tattoos, images of injuries and associated information. In this example, the listeners will hear how the data originates with a local police department, goes to a regional law enforcement center, and to laboratories and national data base systems for processing. The responses are traced through these organizations to illustrate data integrity procedures and how forensic markups are incorporated into the system. The Extended Feature Set for forensic markup of friction print images, anthropomorphic markups of facial images, and the use of DNA information and pedigree trees will be presented. Upcoming additions to the ANSI/NIST-ITL standard will also be addressed. These include dental and oral forensics and bitemark analysis; and investigatory voice biometrics. The illustrative case of the unidentified deceased individual will be expanded upon to show how dental forensics could be effectively used. A separate law-enforcement related scenario will be presented to show how voice and video surveillance data can be effectively incorporated for forensic analysis by using the upcoming supplements to the ANSI/NIST-ITL standard.

Keywords

biometrics, interoperability, identification

Author Bio

Brad Wing is the Biometrics Standards Coordinator at NIST. He is the editor of the ANSI/NIST-ITL standard and participates actively in several other standards organisations, such as ISO, INCITS and OASIS. He has over 20 years experience in the field of biometrics, having worked previously at the US Department of Homeland Security as Biometrics Coordinator, and he also served as co-chair of the Subcommittee on Biometrics and Identity Management of the White House Office of Science and Technology Policy.

2:20 – 2:40 Metrics for Enhancement of Latent Fingerprint Images

Authors:

Peter Bajcsy, NIST Software and Systems Division, 100 Bureau Dr., Mail Stop 8970, Gaithersburg, MD 20899 Andrew Dienstfrey*, NIST Information Technology Laboratory, 325 Broadway, Mail Stop 8910, Boulder, CO 80305 Haiying Guan, NIST Information Access Division, 100 Bureau Dr., Mail Stop 8940, Gaithersburg, MD 20899 Matt Schwarz, Schwarz Forensic Technologies, 2884 Devils Glen Road, #133, Bettendorf, Iowa 52722-3318 Mary Theofanos*, NIST Standards Coordination Office, 100 Bureau Dr., Mail Stop 8940, Gaithersburg, MD 20899 David Witzke, FORAY Technologies, 3911 5th Ave, Suite 300 San Diego, CA 92103

Title

Metrics for Enhancement of Latent Fingerprint Images

Learning Objective

We will demonstrate that image enhancement is both a routine and essential step in the forensic analysis of latent fingerprint images. As such, enhancement merits a detailed analysis of the decision-making process applied during the enhancement process as well as a technical understanding of the software tools used. Preliminary results on both will be presented in this talk.

Impact Statement

The results of this work will provide early components of a foundation for the systematic and scientific basis of latent fingerprint image analysis. We expect similar development of comparable analyses for other image-based methods in forensic sciences in the future.

Abstract

Fingerprint evidence is is routinely used to convict offenders of crimes but such evidence is rarely pristine. Latent fingerprint evidence collected from a crime scene may be incomplete or damaged, may be impacted by lighting, by pressure, or the underlying surface or materials including colors just to mention a few factors. Due to the low signal quality of the fingerprint in relation to other systematic image features—color, pattern, text, etc…—latent fingerprint images are oftentimes unsuitable for feature marking and/or input into fingerprint identification software to search for matches. Confronted with this problem the forensics community currently uses a variety of image manipulation or enhancement tools to improve significantly the quality of these images. The results of these image enhancements can be extraordinary, transforming raw images with little or no value into ones suitable for evidentiary analysis. We will research image metrics and develop well-defined algorithms to analyze and quantify the image transformation processes applied by forensic scientists in the context of latent fingerprint analysis. Finally, we will explore

these newly developed metrics and analysis in the context of the work-flow and decision-making of practicing expert forensic analysts.

Keywords

Latent, Image, Photoshop

Author Bio

Mary Theofanos is a leading authority on usability testing and standards. Her pioneering work in biometrics usability has caused implementation of biometric systems to adopt a more user-centered approach. Theofanos leads a broad effort in usability that makes NIST a premier institution for usability research in the United States. Theofanos serves as a technical expert on the NIJ Expert Working Group on Human Factors in Latent Print Analysis. Andrew Dienstfrey is a mathematician and Manager of the Virtual Measurement Systems Program. This Program focuses on research, development, and application of uncertainty quantification for computationally intensive algorithms.

3:00 – 3:20 Transcending PSNR: SIVV as a Comprehensive Image Fidelity Metric

Authors:

John M. Libert, NIST Shahram Orandi, NIST John D. Grantham, NIST

Title

Transcending PSNR: SIVV as a Comprehensive Image Fidelity Metric

Learning Objective

Attendees of this presentation will 1) better understand deficiencies of the widely used Peak Signal to Noise Ratio (PSNR) and other image differencing schemes as a measures of image fidelity; 2) begin to appreciate the utility of evaluating image fidelity via frequency analysis and specifically using the NIST Spectral Image Validation Verification (SIVV) metric.

Impact Statement

The presentation demonstrates to the forensic community a tool for quantitative measurement of image fidelity that offers significant measurement advantages over the most ubiquitous fidelity metric, the Peak Signal to Noise Ratio (PSNR).

Abstract

Peak Signal to Noise Ratio (PSNR) and related image differencing measures persist as measures of image fidelity in spite of well documented limitations. Such methods are unusable if a process applied to an image changes the dimensions of the image relative to the comparison image. PSNR can produce highly misleading results if image features have undergone some geometric transformation so as to offset corresponding pixels relative to one another. Moreover, comparison of changes in pixel magnitude, even if uncompromised by changes in image geometry, provides little information regarding alteration of image structural components relative to an unprocessed or differently processed exemplar. The authors will present examples of common measurement situations in which PSNR yields spurious results or exhibits sensitivity to image characteristics unrelated to pictorial image content. For each case, the authors will present the contrasting response of a spectral analysis tool developed at NIST that facilitates image quantitative image comparison in terms of the spatial frequency composition of the

images. First documented in NISTIR7599, the NIST Spectral Image Validation Verification (SIVV) metric has demonstrated via a number of recent image compression studies exceptional utility for the measurement of image fidelity. Employing a relatively simple computational approach, the SIVV is able to quantify and partition changes in the spatial frequency composition of an image that might result from such processing as lossy compression. It is being used to evaluate comparative effects of different degrees of image compression using the JPEG2000 CODEC, to compare relative performance of different image compression CODECs, and is being applied to a variety of other measurement issues with biometric data, including fingerprint, face, and iris images.

Keywords

SIVV, Image Fidelity

Author Bio

With a background in image and signal analysis and pattern recognition, John Libert came to NIST sixteen years ago to work on digital video image quality and fidelity measurement. He went on to develop measurement methods and standards for electronic display metrology. Most recently, his work at NIST has been directed toward developing methods related to the characterization of biometric image data, notably measurement of face image quality, fidelity of fingerprint images subjected to various image compression processes, comparative evaluation of image downsampling schemes, and validation and verification of large fingerprint databases.

3:20 – 3:40 Challenges in Forensic Face Recognition

Authors:

P. Jonathon Philips, PhD, NIST, 100 Bureau Dr, Gaithersburg, MD 20899, jonathon@nist.gov

Title

Challenges in Forensic Face Recognition

Learning Objective

After attending this presentation, attendees will understand how grand challenges have advanced automatic face recognition technology since 1993; the key remaining challenges in automatic face recognition, and how these challenges are related to forensic face recognition.

Impact Statement

This presentation will impact the forensic community by establishing the bases for measuring the performance of face examiners and developing computer tools to assist forensic face examiners.

Abstract

Since 1993, the error rate of automatic face recognition systems has decreased by a factor of 272. The reduction applies to systems that match people with face images captured in studio or mugshot environments. In Moore's law terms, the error rate decreased by one-half every two years. Two key factors in achieving this reduction have been periodic independent evaluations and challenge problems sponsored by numerous US government agencies. Independent evaluations provide an unbiased assessment of face recognition system performance. Nineteen years ago, the US government began conducting a series of such evaluations. The first evaluations were part of the F E R E T program, which ran from 1993 to 1997. The Face

Recognition Vendor Tests (FRVT), conducted by NIST, followed in 2002, with a second FRVT in 2006. The most recent evaluation, administered by NIST last year, was the Multiple Biometric Evaluation (MBE) 2010. These evaluations assessed the performance of the technology underlying automatic face recognition. At the start of the FERET program in 1993, performance of a state-of-the-art system had a false reject rate of 0.79 at a false accept rate of 1 in 1000. Seventeen years later, a state-of-the-art system in the MBE 2010 had a false reject rate of 0.0029 at the same false accept rate, which a reduction in the false reject rate by a factor of 272. As impressive as these results are, they do not imply that automatic face recognition is a solved problem. Performance degrades when attempting to recognize faces in images collected outside of studio or mugshot environments. With the active support of NIST in creating new challenge problems, research new directions in automatic face recognition are being encouraged. These challenge problems will assist researchers and industry to develop algorithms to solve the new challenges. Two research directions include recognition from video and point and shot cameras, such as found in cell phones. In unconstrained scenarios, the most robust face recognizers are humans. A third challenge is developing algorithms that are as robust as humans at recognizing unfamiliar faces. Face recognition as characterized by these three challenges cover conditions that forensic face examiners address in their cases. Over the last decade, a series of experiments have systematically incorporated the analysis of human performance into face recognition challenge problems and evaluations. Based on these experiments, for both video and still imagery, it is now possible to compare performance for computers and humans. For frontal face images, these experiments show that machines are superior to normal humans. There are cases where the face does not contain sufficient information to perform recognition. In these cases, humans perform recognition using non-face identity cues; e.g., shape of head, neck, and body. The experimental results show that when recognition requires non-face identity cues, humans out perform machines. In general, the experiments show that human effectively take advantage of all available identity cues to perform recognition; whereas, machines only take advantage of face identity cues. This points to a future research direction, which is critical to developing tools for forensic face analysis. The above experiments measured performance of normal humans. The methodology can easily be extended to measure the performance of super face-recognizers, trained law enforcement professionals, and forensic face examiners. Measuring the performance on these categories of face recognizer would provide a scientific base for characterizing face performance in forensic cases. In addition, it would assist in identifying where face analysis tools could most effectively assist forensic examiners.

Keywords

face, recognition, evaluations

Author Bio

Dr. Jonathon Phillips is a leading technologist in the fields of computer vision, biometrics, and face recognition. He is at NIST, where he runs challenge problems and evaluations to advance biometric technology. In an Essential Science Indicators analysis of face recognition publication, Dr. Phillips' work ranks at #2 by total citations and #1 by citations per paper. His work has been reported in the New York Times and the Economist. He has appeared on NPR's Science Friday show. He is a fellow of the IEEE and IAPR. He was awarded the Dept. of Commerce Gold Medal.

3:40 – 4:00 Human Assisted Speaker Recognition

Authors:

Craig S. Greenberg, M.S. Alvin F. Martin, Ph.D. Mark A. Przybocki, M.S. John J. Godfrey, Ph.D.

Title

Human Assisted Speaker Recognition

Learning Objective

Having attended this presentation/demonstration, audience members will understand some of the challenges that audio data presents to forensic speaker recognition experts and the need for scientific evaluation and performance measurement.

Impact Statement

This work impacts the forensic community and/or humanity by measuring speaker recognition capabilities under some of the conditions present in forensic applications and providing a common and comprehensive research and evaluation framework, enabling greater rigor in the field.

Abstract

NIST began working in the area of speaker recognition in 1996 by holding the first in what became an ongoing series of evaluations of text independent speaker detection. The 2010 NIST Speaker Recognition Evaluation (SRE10) included for the first time a test of Human Assisted Speaker Recognition (HASR) in which systems based in whole or in part on human expertise were evaluated. Some of the factors present in forensic speaker recognition were controlled in the HASR test data to enable research, so this exciting pilot study, while informative to the forensic community, should not be considered a true or representative forensic test. Two HASR trial sets were offered, the first including 15 trials, and the second a superset of 150 trials. Results were submitted for 20 HASR systems from 15 sites from 6 countries. The trial sets were carefully selected by a process that combined automatic processing and human listening, to include particularly challenging trials. The performance results suggest that the chosen trials were indeed difficult, and the HASR systems did not appear to perform as well as the best fully automatic systems on these trials. In this talk/demonstration, the authors will present audience members with some of the voice recording used in the first HASR evaluation, will go on to highlight insights gained from the resulting research, and will share plans for the next HASR evaluation to be held in Autumn of 2012.

Keywords

HASR; Speaker; Recognition

Author Bio

Mark Przybocki, Alvin Martin, and Craig Greenberg have 10, 16, and 4 years' experience (respectively) evaluating speaker recognition technology at NIST. John Godfrey spent 10 years at UT-Dallas as an Associate Professor, served as the first Executive Director of the Linguistic Data Consortium, and has been a Chief Scientist in the U.S. Department of Defense since 1999.

SELECTED POSTER: Using Attack Graph and Evidence Graph in Computer Forensics Examinations

Authors:

*Anoop Singhal Ph.D., Changwei Liu, Duminda Wijesekera anoop.singhal@nist.gov, cliu6@gmu.edu, dwijesek@gmu.edu *National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg MD 20899. Department of Computer Science, George Mason University, Fairfax VA 22030

Title

Using Attack Graph and Evidence Graph in Computer Forensics Examinations

Learning Objective

The objective of this presentation will be to learn about the problems and challenges of forensic examinations in large enterprise computer networks.

Impact Statement

In this presentation we will demonstrate how a methodology based on "Attack Graphs" and "Evidence Graphs" can be used to help forensics investigators determine how a cyber attack was launched.

Abstract

Graphs have been useful for forensics analysis. In particular, two kinds of graphs are involved in forensics analysis field. They are attack graphs and evidence graphs. Attack graphs are used to compute potential attack paths from a system configuration and known vulnerabilities of a system and evidence graphs model evidence of intrusive behavior and dependencies among them used by forensic examiners. Linking available evidence after an attack provides some intuition into the attack scenario. Constructing an evidence graph from linked evidence further refines the attack scenario. Given that there are anti-forensic tools that can obfuscate, minimize or eliminate evidence, forensic analysis becomes harder. As a solution, we propose to use attack graphs (that provide theoretical possible attack paths), ways in which evidence could be missing due to the use of anti-forensics tools. We do so by including anti-forensics activity nodes into the attack graph and modeling the dependency between such a node and its ability to prevent a forensic tool from being used. This addition to the attack graph does not add any complexity to the original attack graph, but provides the investigators explanation why the evidence is missing and suggests how to recover the missed evidence or the real attack scenario. In order to construct such an effective anti-forensics activity node and model its dependency between the node and the anti-forensics technique/tool, a database that includes all anti-forensics techniques/tools for specific attacks is required. In particular, we propose to enhance repositories like the National Vulnerability Database (NVD) to collect capabilities of anti-forensic technique or tools as an

enhancement to NVD in order to assist forensic examinations. We show by using an example how an attack graph enhanced with anti-forensics activities could account for missing evidence during a forensics examination, and what information ought to be provided by NVD in order to assist forensic examiners. Conversely, an evidence graph can also be used to refine attack graphs of a given enterprise. Typically, an attack graph is generated from vulnerability information provided in bug-reports about a specific network configuration. However, it is entirely possible that some vulnerability is used in launching an attack, but it becomes known after being exploited by attackers. In such a case, a linked set of evidence provided by an evidence graph can be used to enhance the originally incomplete attack graph by adding the missing attack paths. In turn, a valid and more comprehensive attack graph with proper cumulative vulnerability metrics that indicate attack success at specific steps can be helpful to forensic examiners. In order to fully utilize this dual use, a proper mapping of attack graphs to evidence graphs becomes useful. We show how to create such a mapping with all the vulnerability metrics on the attack graph side and potential attack scenario probabilities on the evidence graph side. One of the immediate benefits of this exercise is the ability to refine the attack and evidence graphs. A comprehensive case study using an experimental network and a database attack shows the utility of our research.

Keywords

computer attacks

Author Bio

Dr. Anoop Singhal, is currently a Senior Computer Scientist in the Computer Security Division at NIST. His research interests are in network security and forensics, web services security and data mining systems. He is a senior member of IEEE and he has published several papers in leading conferences and journals. He has given a talk at several computer security conferences such as ACSAC, ACM CCS and RSA. He received his Ph.D. in Computer Science from Ohio State University, Columbus, Ohio.

SELECTED POSTER: 3D Shape Analysis, Retrieval and Metrology

Author

Afzal Godil

Title

3D Shape Analysis, Retrieval and Metrology

Keywords:

Shape Analysis; Shape Retrieval; Shape Metrology; Shape Retrieval Contest; Applications

Abstract:

With recent advances in 3D imaging, scanning and modeling technologies, large number of 3D models are created and stored in different databases. For these databases be used effectively require methods for analysis, retrieval, and classification. Therefore, analysis and retrieval of 3D objects are becoming an increasingly important task in modern applications such as computer vision, multimedia , computer aided design/computer aided manufacturing, robotics, cultural

heritage, molecular biology, biometric and security. This has created an impetus to develop effective 3D shape analysis and retrieval algorithms for these domains and has made it an active area of research in the 3D community. One of the most important research problems in this field is the development of shape descriptors. In this poster we will present some of the 3D shape descriptors that we have developed for different domains and for articulated and partial shape retrieval.

Finally, we have developed different 3D shape retrieval benchmarks and evaluation tools, and have organized nine Shape Retrieval Contest tracks under the EuroGraphics-Workshop on 3D Object Retrieval. This metrology work is an important step toward confirming the reliability of 3D Shape Analysis and Retrieval for commercial applications

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SELECTED POSTER: An Alternate Methodology for Validating Hardware Write Block Devices

Authors

Benjamin R. Livelsberger, MS*, National Institute of Standards and Technology, 100 Bureau Drive Stop 8970, Gaithersburg, MD 20899-8970

Title

An Alternate Methodology for Validating Hardware Write Block Devices

Learning Objective

The Computer Forensics Tool Testing (CFTT) project at NIST has developed an alternate methodology for validating Hardware Write Block (HWB) devices. After attending this presentation, attendees will be familiarized with this methodology and the benefits it offers.

Impact Statement

The current methods used to validate HWBs have an inherent weakness. This presentation will have the impact of educating the audience to the nature of this weakness and to an alternate NIST-developed method that seeks to account for it.

Abstract

Before being used in an investigation the correct functioning of a forensic tool must first be established. For Hardware Write Block tools this involves testing 1) that the HWB allows informational and read commands to be passed to the drive and their responses to be returned to a host computer and 2) that it blocks modifying commands from reaching the protected drive. The current commonly used method for validating a HWB involves using forensics tools and/or common Operating System utilities and operations to attempt to read and write to a protected drive. There is a weakness inherent in this approach, namely that it only tests a small subset of the commands that could be used to read from or write to a drive. For example, testing a HWB's ability to block modifying commands by attempting a file copy operation to a protected ATA drive using an Operating System that implements the WRITE DMA EXT command for ATA devices will only test the hardware write block's ability to block the WRITE DMA EXT command; it will not test whether the HWB blocks the WRITE SECTORS EXT or WRITE MULTIPLE EXT commands. In this scenario, a malfunctioning HWB that incorrectly allows the WRITE MULTIPLE EXT command to be passed to protected drives will not be identified as faulty. A more thorough approach, one that tests the HWB's behavior with a broader range of

commands than those implemented by a given Operating System is desirable. The Computer Forensics Tool Testing project at NIST has developed an alternate methodology for validating HWBs. With this methodology, testing is not limited by the subset of commands implemented by the Operating System being used. HWBs are instead tested with all read and write commands as defined in ATA specs 4-8 and SCSI Block Commands-2 and as implemented by an extended version of the ataraw Linux library written by Kyle Sanders and Simson Garfinkel of the Naval Post Graduate School. Three Linux programs were written to implement the CFTT methodology. These programs tie into the ataraw library to send ATA or SCSI commands to devices via the Linux SCSI Generic driver. The three programs are: try_read sends all defined SCSI or ATA read commands to a drive, try_write sends all defined SCSI or ATA write commands to a drive, and write_verify measures whether any hard drive sectors have been successfully written to. Using these programs, a HWB tool may be validated in the following manner: 1. For each hard drive interface supported by the HWB, initialize a drive with to known content. 2. Calculate a before reference hash for each drive. 3. For each permutation of host-to-blocker and blocker-to-drive interfaces execute the try_read and try_write programs. 4. Calculate an after reference hash for each drive. 5. Use write_verify and a comparison of the reference hashes to measure whether any sectors on the test drives have changed. This work will support Federated Testing.

Keywords

Digital, Testing, Forensics

Author Bio

Ben is a computer scientist at the National Institute of Standards and Technology (NIST). He's worked at NIST since 2003 where he's tested forensic tools, published test reports, and written test support programs for the Computer Forensic Tool Testing project. Ben received a B.A. in Computer Science from Gettysburg College in 2003 and a M.S. in Information Systems and Technology from Johns Hopkins University in 2011.

SELECTED POSTER: NSRL Policy and Procedure for Downloaded Software

Authors:

John Tebbutt

Title

NSRL Policy and Procedure for Downloaded Software

Learning Objective

After attending this presentation, attendees will understand the means by which the NSRL captures downloaded software, catalogs its provenance, and otherwise ensures the forensic soundness of the metadata derived from it.

Impact Statement

The impact of this presentation on the forensic and other communities will be in the transparent documentation of the procedures used by the NSRL to derive forensic metadata from downloaded software. As a result the NSRL's methods are testable, repeatable and verifiable by any interested party.

Abstract

This presentation will provide a detailed description of the set of best practices used by the

NSRL for the collection and processing of downloaded software. The end product of this set of procedures is the publication of metadata from downloaded software which is incorporated into the NSRL RDS. Traditionally the NSRL collected only shrink-wrapped, off-the shelf software, storing the original, physical, read-only media in the NSRL library.The reasons for this related primarily to the need for traceability from the file metadata released in the NSRL RDS, back through a chain of custody to the original media on which the software was distributed. This model worked well, but with the side effect that software which is available only through download had to be excluded, limiting the coverage of the RDS and detracting from its utility as source of trustworthy file metadata. This presentation documents and makes transparent the methods by which the NSRL collects and processes downloaded software in such a way as to render the published metadata as reliable and traceable as those for physical media.

Keywords

software downloads metadata

Author Bio

John has worked in digital forensics for over ten years, concentrating on the provision of standardized data to domestic and international law enforcement agencies. Prior to that his focus was on the development of open standards for data interchange, including working on the W3C XML Schema Working Group and with ISO/CCITT on X.500/LDAP. He has also worked in automated hypertext linking and text retrieval/search technologies. John Joined NIST in 1987.
