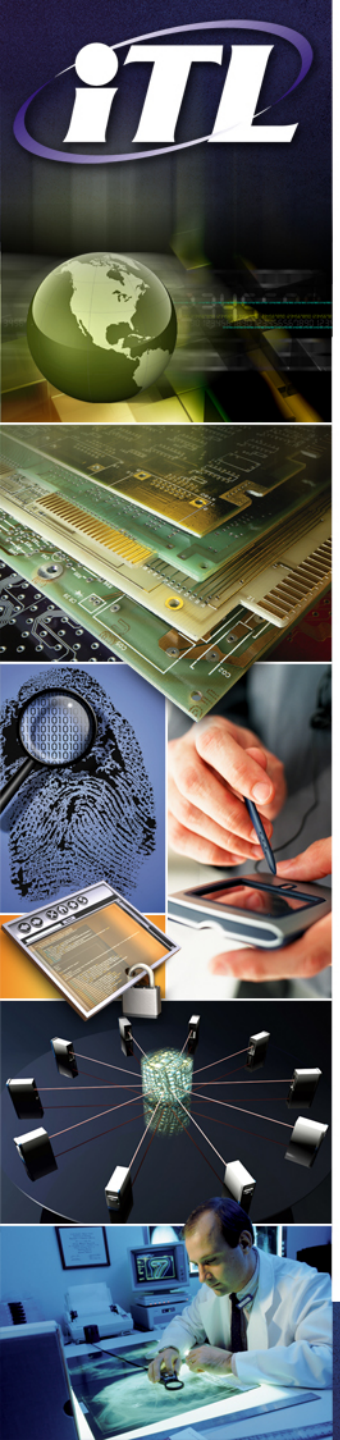

Strategic Research Directions in Forensic Science & Information Technology at NIST

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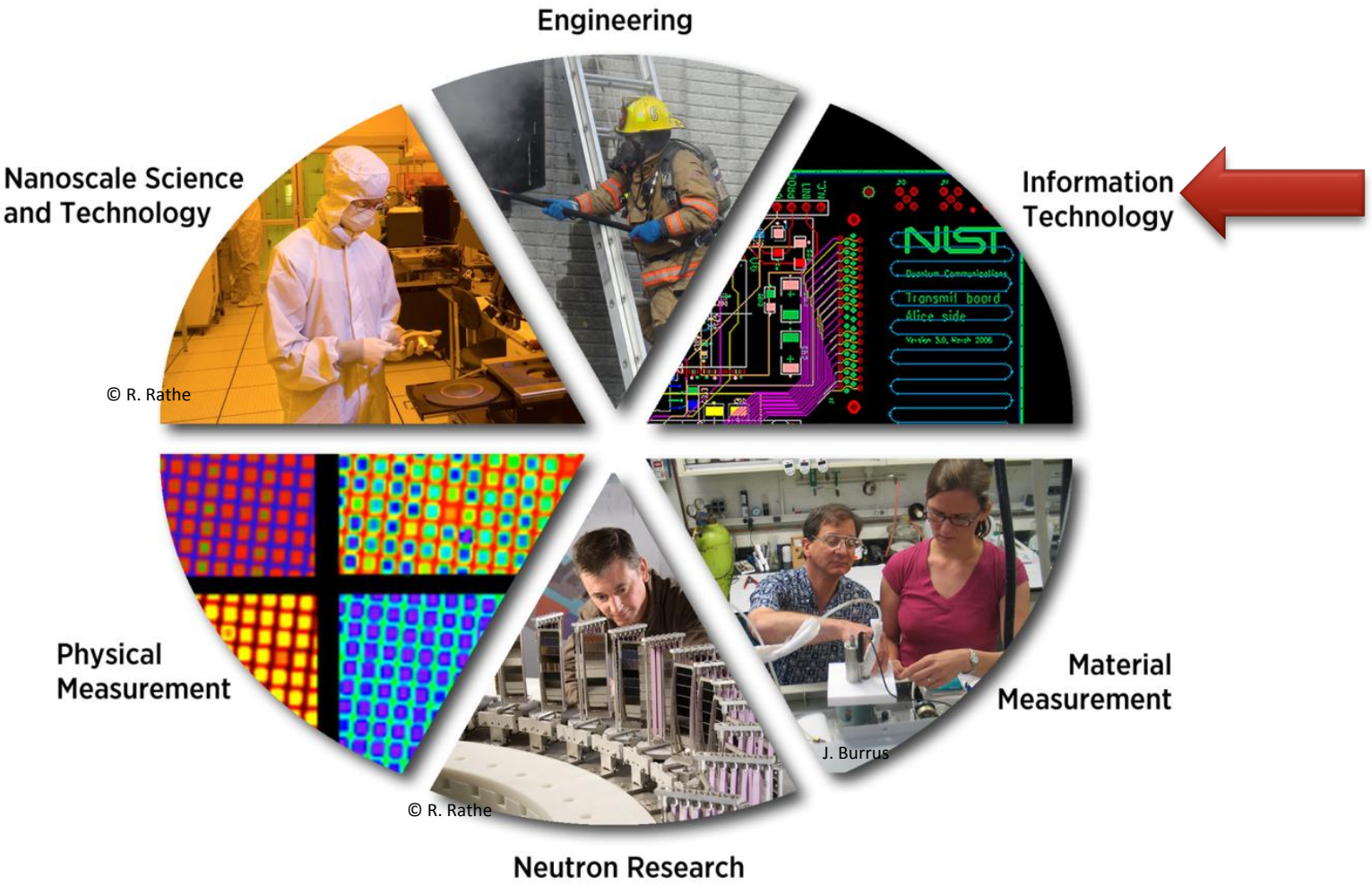
Outline

- Overview and mission of NIST Information Technology Laboratory (ITL)
- Examples of past ITL accomplishments in forensics
- Strategic research challenges
- Addressing the research challenges

NIST Laboratories



Information Technology Laboratory (ITL)

ITL Mission:

To promote US innovation and industrial competitiveness by advancing

measurement science, standards, and technology

through research and development in

information technology, mathematics, and statistics.

- Computer Security
- Mathematics (Applied & Computational)
- Networking
- Statistics
- Software
- Information Access
- Usability
- Biometrics
- Video & audio analytics
- Cloud Computing
- Complex Systems
- Forensic Science
- Health Information Technology
- Trusted Identities in Cyberspace
- Pervasive Information Technology
- Quantum Information
- Smart Grid
- Voting Standards
- Virtual Measurement Systems

Examples of Past ITL Accomplishments in Forensics

Achieving greater reliability, accuracy, validity and throughput of forensic analyses

ANSI/NIST-ITL Standard

- Basis for biometric data exchange
- Enhances reliability and throughput of biometric identification
- Required to exchange fingerprints with FBI, RCMP, NATO, DoD, DHS, INTERPOL, other organizations in 100 nations

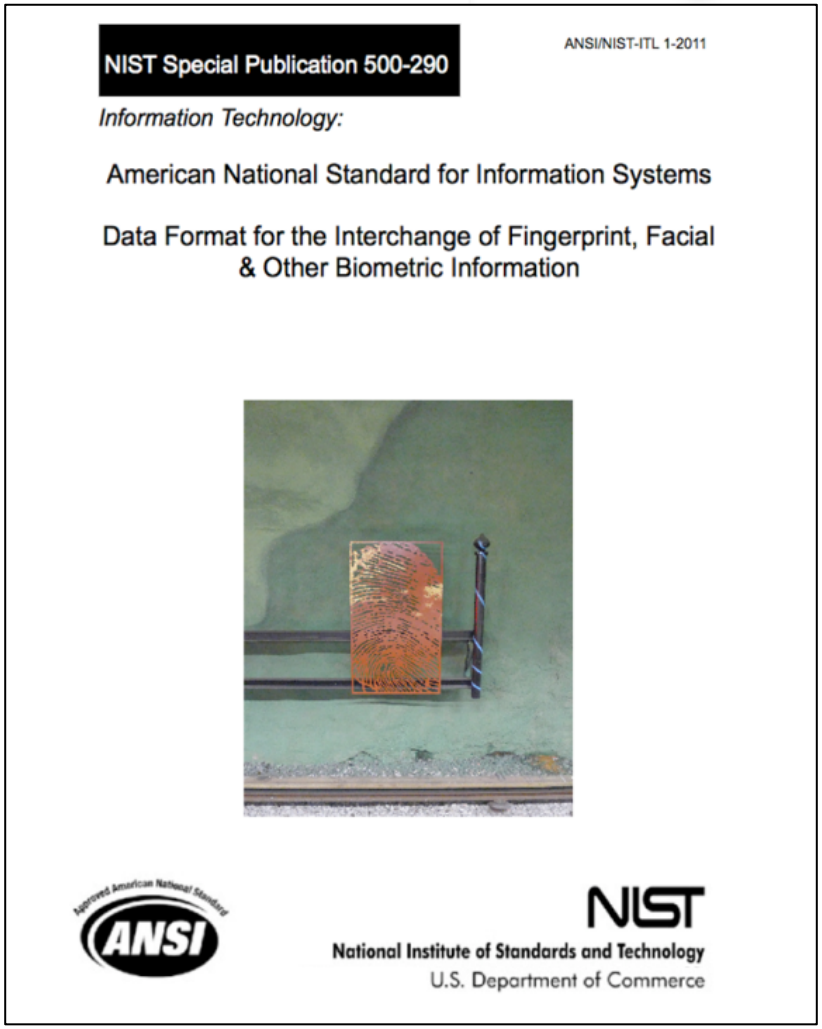
* Fingerprints, Palmprints & Footprints (Exemplars & latent prints)

* Forensic Markups of Images (2D & 3D feature points, contour mapping, extended feature set markups for latent prints)

* Iris * DNA * Associated Images

* Body Images (Face, Scars, Marks, Tattoos, Pattern Injuries, Identifying Characteristics)

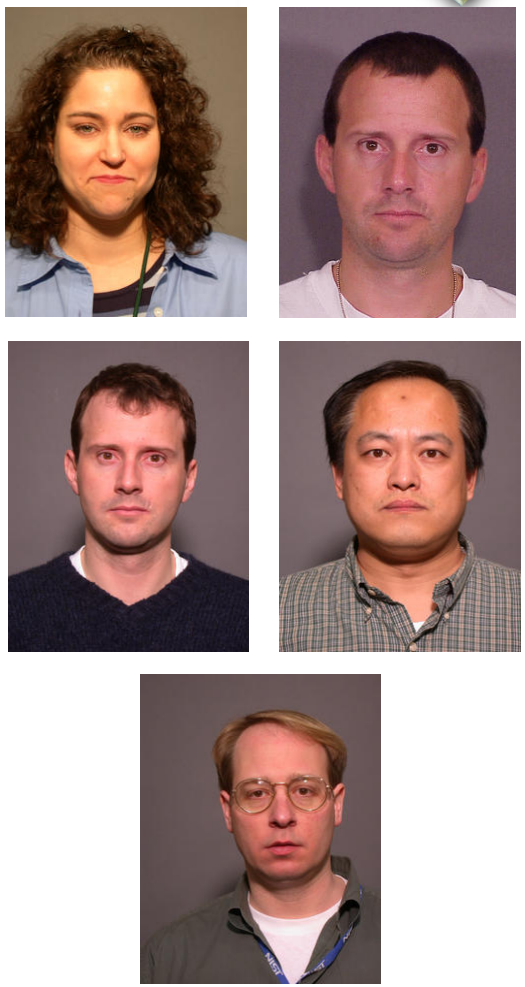
* Dental forensics * Voice



Contact: Brad Wing, NIST

ITL Face Recognition Test & Evaluation

- Independent government evaluations of commercial and prototype Face Recognition technologies
- Tests recognition performance of systems
- Results help identify future research directions
- Has resulted in driving down error rates in state-of-the-art systems by two orders of magnitude in last 20 years



Contacts: Jonathon Phillips, NIST
Patrick Grother, NIST

National Software Reference Library

- Used to identify software resident on digital media
- Enhances reliability, accuracy, repeatability and throughput in computer forensics
- Used daily by virtually all computer forensics operations in the U.S. (and many internationally)
- Both criminal and civil investigations

* NSRL collects software from various sources

* Computes file profiles from the software into a Reference Data Set (RDS)

* RDS used by law enforcement, government, and industry to review computer files by matching against the RDS

* Most common use: Alert/ignore - Eliminate known files and identify interesting ones

Contacts: Barbara Guttman, NIST
Doug White, NIST

Computer Forensic Tool Testing

- Scientific test methodology and testing for computer and mobile-device forensic tools
- Determines reliability and validity of tools
- Helps users select appropriate forensic tools; helps toolmakers improve tools
- Helps determine Daubert admissibility of tools in legal proceedings

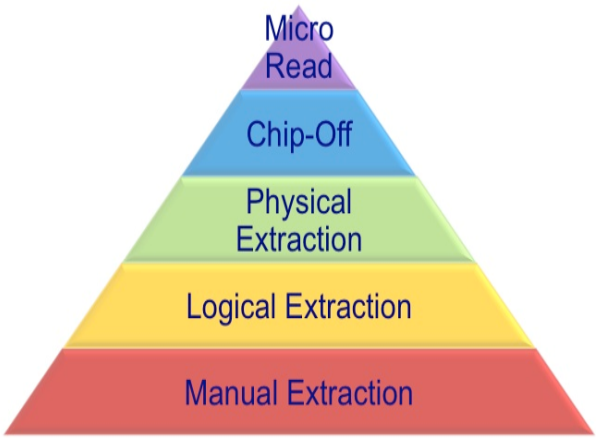
* Disk Imaging

* Hard Disk Write Blocking * Software Blocker

* Deleted File Recovery *File carving

* Drive erase/wipe *String Searching

* Mobile Devices * Memory Analysis



Contacts: Barbara Guttman, NIST
James Lyle, NIST
Rick Ayers, NIST

Current Forensics Projects in ITL

Measurements, Standards, & Technology

- **Forensic Human Identity**
  - Fingerprints (latent & ten-prints)
  - Face recognition
  - Speaker recognition
  - Palm prints, plantars (footprints)
  - Iris recognition, DNA, tattoos
  - Dental records, bite marks
- **Digital Forensics**
  - Computer forensics
  - Mobile device forensics
  - Cloud computing forensics
  - Cybersecurity incident handling
- **Multimedia Forensics**
  - Video/image/audio analytics and content extraction
    - Surveillance & multimedia event detection and recognition
    - Search for persons, objects or places
    - Person tracking
- **Statistics for Forensics**
  - Statistical analysis for
    - Illicit drug measurements
    - Markings on bullets & casings
    - Ballistic markings database and matching

Goals of ITL Forensic Science

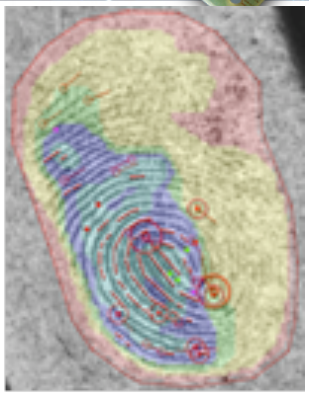
Advance measurements and standards infrastructure for forensic science through computer science, math, statistics and human factors.

Goals:

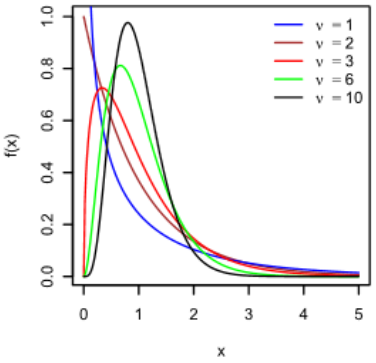
- Improve accuracy and reliability
- Determine sources of human error and reduce human observer bias
- Develop scientific underpinnings
- Determine scientific and statistical validity of forensic methods and standards
- Establish statistical foundations, including measures of uncertainty
- Develop computing technologies and reference data
- Enhance usability and interoperability

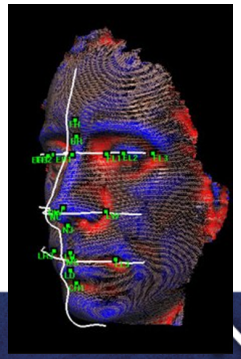
NAS Report

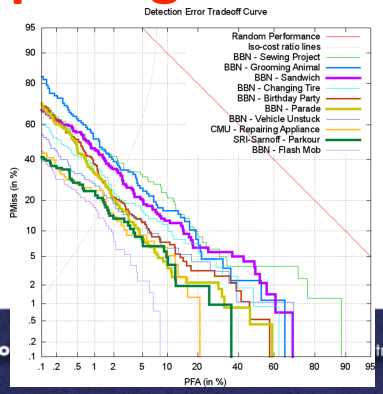
ITL Critical Themes in Forensic Science

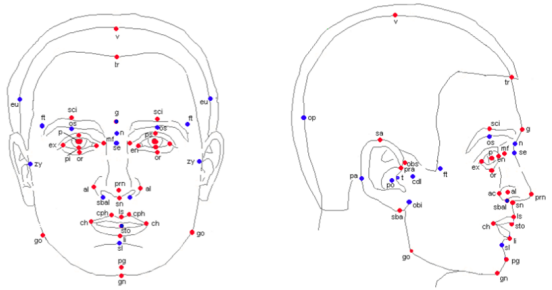


- Image and Pattern Analysis
- Measurement and Uncertainty
- Interoperability of Forensic Data
- Automated Forensic Computing Technologies





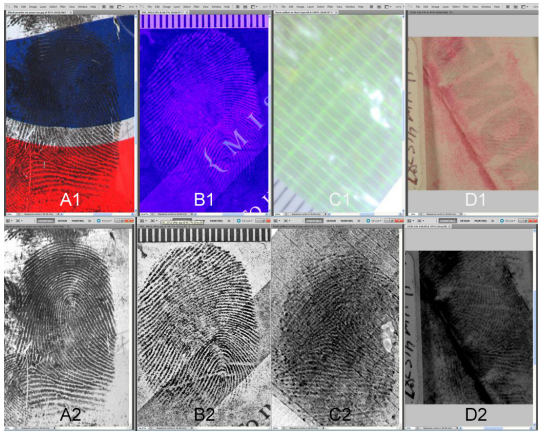




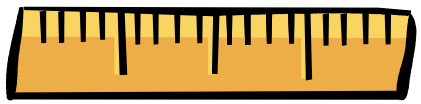
Strategic ITL Research Challenges in Forensics

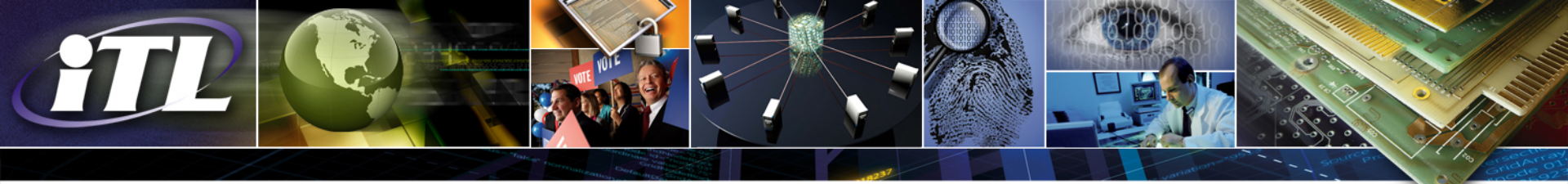
- Scientific underpinnings
- Statistical foundations
- Validation studies
- Human bias and error
- Computing technologies and reference data
- Usability
- Interoperability

Scientific Underpinnings Challenges



- Wide variability in scientific foundations across forensic science disciplines
  - Particular issues in pattern-based and digital forensic disciplines
- **Need to solidify underpinnings in measurement science and technology for pattern-based forensics and digital forensics**
- **Research needed to address accuracy, reliability, and validity**





Potential ITL Research to Address Scientific Underpinnings

- Measures for quality of pattern data and digital data
- Measures for reliability, repeatability, reproducibility, accuracy, validity (in pattern and digital disciplines)
- Measurement science to advance pattern-based forensics
  - Variability in features of patterns
  - Information content of patterns
  - Characterization of search and matching
  - Characterization of signal and image processing techniques
- Measurement science to advance digital forensics
  - Cloud computing
  - Mobile devices
  - Multiple devices and operating systems
  - Pervasive encryption
  - Explosion in size of storage, file formats, data
- Metrology for real-time, in-the field analysis in pattern & digital forensics
- Theoretical limits of reliability and accuracy

Specific Examples

- AFIS scientific underpinnings
- Quality measures of latent prints
- Superimposed friction ridge marks
- Characterize latent image enhancements
- Data quality for forensic speaker recognition
- Impression evidence: measures of information content, probability models, statistics of comparisons
- Network forensics underpinnings
- Cloud computing forensics
- Quality of video, audio, and images
- Bloodstain Image enhancement/ analysis
- Forensic shape metrology:
  - matching of hair and fibers; teeth and their marks, skulls and bones; particles from explosives, cements, sand, etc.; tattoos and tire/shoe impressions

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Statistical Foundations for Forensic Science

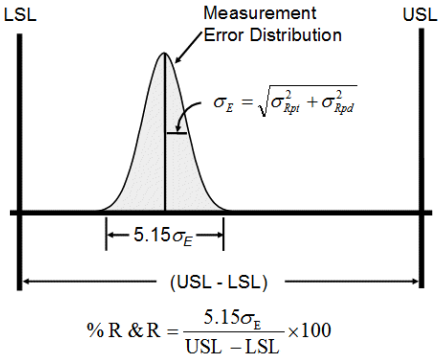
NIST currently participates with BIPM in GUM and VIM to provide basis for measuring uncertainty

GUM: Joint Committee for Guides in Metrology. ***Evaluation of measurement data – Guide to the expression of uncertainty in measurement*.** International Bureau of Weights and Measures (BIPM), Sèvres, France, September 2008.

VIM: Joint Committee for Guides in Metrology. ***International vocabulary of metrology – Basic and general concepts and associated terms (VIM).*** International Bureau of Weights and Measures (BIPM), Sèvres, France, 2008.

Statistical Foundations Challenges

- In many forensic disciplines, there is no well-defined system for determining error rates
- **Establish uniqueness of marks or features in patterns**
- **Develop improved measures of uncertainty for forensic measurements and for conclusions of forensic tests and analyses**
- **Develop additional statistical tools and practices and integrate them into forensic tests and analyses**



Potential ITL Research to Address Statistical Foundations

- Metrology and methodology for determining error rates
- Improved measures for uncertainty
- Statistical tools for extracting/analyzing digital evidence
- Statistical tools to establish uniqueness of features in large populations
- Statistical tools/techniques for use by practitioners to ensure
  - use of proper experimental design in testing evidence
  - proper statistical analysis of test results
  - formulation of valid forensic inferences
- Statistical tools for use in validation studies

Specific Examples

- Latent fingerprints:
  - Measures of information content, probability models, and statistics of comparisons
- Handwriting:
  - Quantify conclusions
  - Uncertainty determination
  - Uniqueness of handwriting features
- Uncertainty measures in digital forensics
- Uncertainty measures in 3D crime scene models
- Statistical tools to interpret trace evidence or toxicology levels

Strategic ITL Research Challenges in Forensics

- Scientific underpinnings
- Statistical foundations
- Validation studies
- Human bias and error
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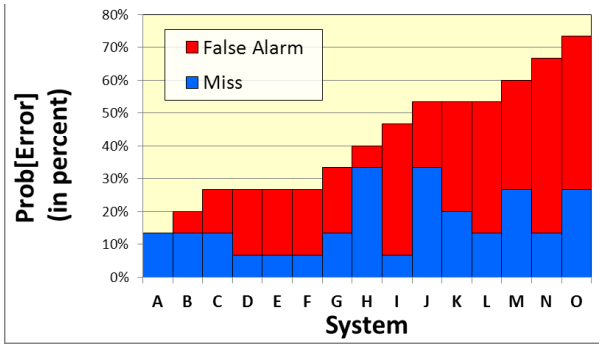
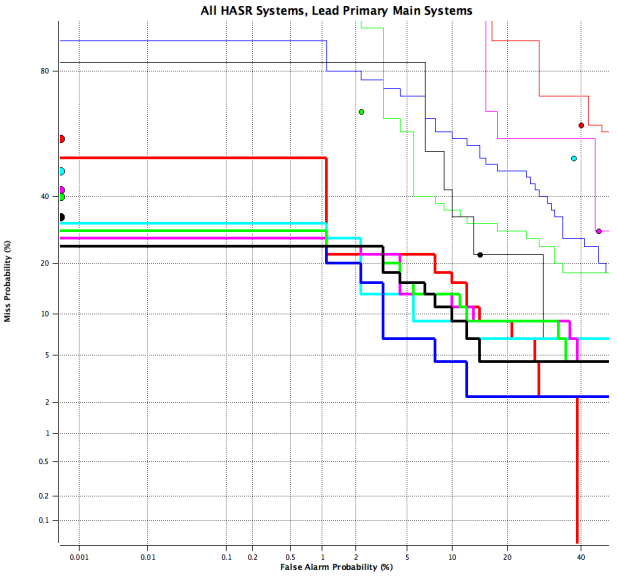
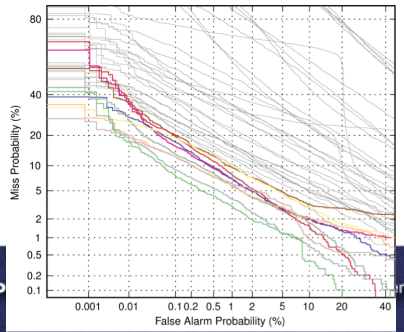
- Usability
- Interoperability

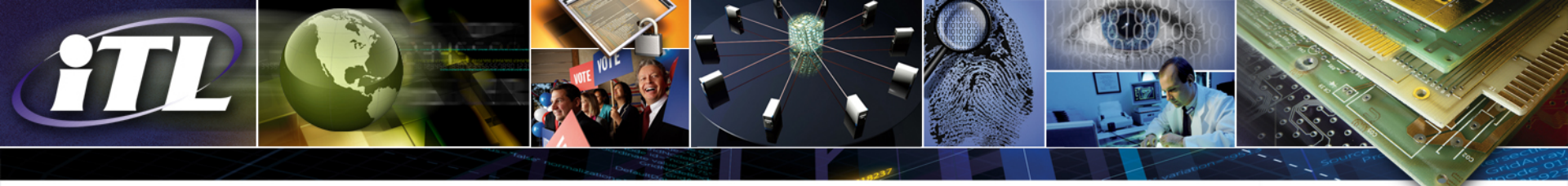
Validation Challenges

- **Many forensic methods, practices, and technologies need further validation, including**
  - **Pattern-based forensics**
  - **Digital forensics**
  - **Interoperability standards and technologies**
  - **Automated computing technologies**
- **Validation studies are needed that determine how well these approaches perform under a variety of conditions of use**









Potential ITL Research to Address Validation Studies

- Rigorous methodology for validating forensic methods, standards, practices, and tools
  - Accuracy and reliability required to be scientifically and statistically determined under a broad range of conditions
  - Estimate uncertainty or errors
- Metrology and methodology for determining strengths and limitations of forensic procedures
- Develop testbeds for performing validation tests and experiments

Specific Examples

- NIST Computer Forensic Tool Testing (CFTT)
  - E.g., volatile memory and live forensics, triage, timelining
- Forensic speaker recognition evaluation series
  - Test and evaluation of automated systems
  - T & E of combined human experts and automated speaker recognition
- Automated latent AFIS:
  - Large-scale benchmark evaluations: automatic feature extraction and matching as well as standardized features hand-marked by human experts
- Quantitative computer models and metrics for bloodstain pattern formation

Strategic ITL Research Challenges in Forensics

- Scientific underpinnings
- Statistical foundations
- Validation studies
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Human Bias and Error Challenges

- **Need to understand sources of unconscious bias**
- **Need to develop mitigation strategies**
- **Need to develop test methodology to determine and evaluate human error and the sources of error**
- **Need to develop metrology to characterize and quantify human error**

Potential ITL Research to Address Human Bias and Error

- Work-flow studies of practitioners to develop sources of human bias and error
- Measure repeatability and reproducibility of practitioner practices
- Metrology for human error
- Develop, test, and evaluate mitigation strategies

Specific Examples

- Latent examiner bias: metrology, test methodology
- Handwriting examiner bias, errors, and decision-making
- Work-flow studies on bloodstain pattern examiners to determine human bias, errors, decision making
- NSF Workshop* recommended studies, e.g., Study #3:

  What are examiners doing during forensic comparisons?
  - What details do they look for and what is the degree of variability among qualified examiners?
  - Do examiners use implicit decision rules for drawing conclusions?

* Workshop on Cognitive Bias and Forensic Science, Northwestern University School of Law, September 23-24, 2010

Strategic ITL Research Challenges in Forensics

- Scientific underpinnings
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Computing Technologies and Reference Data Challenges

- Computing technologies and reference data sets can lead to greater accuracy, reliability, functionality, and throughput
- **New technologies and data sets need to be developed, tested and validated**

Potential ITL Research to Address
Computing Technologies and Reference Data

- Test/evaluate effectiveness of computing technologies for forensic analysis
  - Existing technologies
  - New technologies
- Test proposed standards, guidelines, validation methods, and user interfaces related to automated computing technology
- Develop testbeds
- Foster innovation through challenge problems
- Develop and validate reference data sets

Specific Examples

- Accelerate AFIS latent matching through large-scale open evaluations
- Automated face recognition systems: evaluations to accelerate technologies for robust recognition
- Content-based video search challenge problems and evaluations
- Evaluations of automated handwriting search and matching
- Forensic text analysis: Accelerate technologies through evaluations
- Content-based event detection in video: Accelerate technologies through evaluations
- DNA software tools
  - Expert system tools to help the DNA practitioner become more productive and improve DNA data quality

Strategic ITL Research Challenges in Forensics

- Scientific underpinnings
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