National Institute of Justice’s Fingerprint Research & Development

John Morgan
Deputy Director for Science and Technology
National Institute of Justice
General Forensics Research & Development Program
Fingerprint Projects
Purpose: Serve as a focal point for research and development of new tools and technologies to support the criminal justice system at the Federal, State, and local levels.

Goals:

1. Faster, more reliable, more widely applicable, more rugged, less costly, or less labor-intensive tools for identification, collection, preservation, or analysis of crime scene evidence.

2. Tools that can increase the discriminatory power of forensic analyses or provide quantitative or statistical data that can increase the power of a match.

3. Identification or characterization of new analytes of forensic importance.
What is General Forensics?

General Forensics consists of the following 15 disciplines*:

- Biology
- Controlled Substances
- Crime Scene
- Firearms/ Toolmarks
- Forensic Anthropology
- Forensic Engineering
- Forensic Entomology
- Forensic Pathology
- Forensic Odontology
- Forensic Psychiatry and Psychology
- Friction Ridge Identification
- Impression Evidence
- Questioned Documents
- Toxicology
- Trace Evidence

* Definitions are derived from ASCLD\Lab manual and the General Forensics Technical Working Group
How do we meet the needs of the community?

The role of the General Forensic TWG is to identify, discuss, and prioritize operational needs and requirements to ensure that NIJ’s ongoing and planned research and development activities continue to meet practitioner-driven needs.

General Forensics Technical Working Group (TWG)

**Members:** 24 Practitioners
- experience
- professional reputation
- have responsibility for implementing technology tools and systems within their agencies
- geographic, demographic and organizational distribution

**Meeting:** Bi-annual meetings (first meeting was April 05)
## General Forensics Portfolio
### Active Awards

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Quantitative Research on Friction Ridge Patterns Solicitation

In January of 2005 NIJ released a solicitation for quantitative studies of friction ridge skin pattern variations relevant to fingerprint and/or palmprint comparisons for the purpose of identification or exclusion.

Suggested Areas of Research:

A. Quantitative studies of friction ridge skin pattern variations relevant to fingerprint and/or palmprint comparisons for the purpose of identification or exclusion. The research methodology should ensure that adequate population size and proper sampling methods are used. Proposals should focus on the evaluation of one or more of the following characteristics in either a complete or partial fingerprint and/or palmprint impression:
   1. Pattern type and ridge flow (Level I).
   2. Ridge endings, bifurcations, and dots (Level II).
   3. Ridge and pore morphology (Level III).
   4. Incidental features such as creases (both permanent and age-related), scars, warts, and others.

B. Tools that will provide a quantitative measure/statistical evaluation of the following:
   1. The quality of fingerprint and/or palmprint impressions.
   2. The strength of fingerprint and/or palmprint comparison data.
## Active Friction Ridge Projects

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<td>International Association for Identification</td>
<td>Interoperability of AFIS Systems for Latent Print Searches</td>
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<td>International Biometric Group, LLC</td>
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<td>Mountain State University</td>
<td>Breakable cartridge Cyanacrylate fingerprint development system/3 port sublimation chamber</td>
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Human expertise includes changes in both low-level perceptual and high-level cognitive processes. Many of these processes are difficult to verbalize, and thus we turn to empirical methods to infer the nature of these processes. Indiana University is using a combination of behavioral testing and eyetracking to measure the information that experts and novices acquire when they perform tasks that are similar to latent print examinations. Machine learning algorithms is then used to identify the set of features that each group relies on. The larger goal of the project is to create mathematical descriptions of the processes that underlie performance in these tasks, which can then be used to improve machine-based algorithms that match fingerprints.
Interoperability of AFIS Systems for Latent Print Searches

*International Association for Identification*

This project will examine the number of latent print identifications made: (1) without the use of any AFIS system, (2) with the use of the primary AFIS system, (3) with the use of an interstate AFIS system, and (4) with the use of the CJIS system. The primary site will be the NYPD Latent Print Unit Major Crimes Section with the primary search being conducted on the AFIS database maintained by the New York State Division of Criminal Justice Services (DCJS). The interstate AFIS system would include the States of New York and State of New Jersey.
International Biometric Group (IBG), Aprilis Inc., and the Crime Scene Services Section of the Massachusetts State Police (MSP-CSSS) propose a 9-month, 2-Phase research Project in response to NIJ SL 000698. The Project examines the distinctiveness and permanence of Level III features, using Aprilis hardware that captures Level III features and Aprilis software that compares Level III features. This Project will quantify the accuracy of Level III features, support Level III technology implementation decisions, and improve the accuracy and usability of tools available for use for friction ridge analysis. Level III characteristic distinctiveness and permanence is evaluated through collection and processing of card-based and live-scanned fingerprints at resolutions from 500ppi to 4000ppi.

Phase I encompasses the following activities:
- Collection, processing, and encoding of 36,000 fingerprint images at resolutions of 1000ppi, 2000ppi, and 4000ppi through Aprilis scanners
- Processing and encoding of 19,000 legacy optical fingerprint images (500ppi) through Aprilis software
- Scanning, processing, and encoding of 5000 index fingerprint images (4000ppi) from paired tenprint cards with aging of up to several years
- Classification and regional sub-sampling of friction ridge images
- Comparison of 50% of impostor and same-subject images based on Level III features, generating distinctiveness and permanence statistics based on matching errors
The projects will investigate how liquid-to-liquid chemical reaction (monomer-to-polymer) transition time between the CAE monomer and various catalysts can be extended thereby increasing the volume of micro-crystalline vapors generated and, thus, the development of fingerprints (via further polymerization). Preliminary testing shows success. In phase I, MSU will investigate alternative catalysts such as potassium acetate, ammonium hydroxide, glacial acetic acid, and linoleic acid as well as catalysts in mineral oil. In Phase II activities will be centered around the incorporation of sublimation dyes to render a colored polymer. Phase III includes the expansion of the 1992, NIJ-sponsored Vapor Wand Project to make a “portable mobile ‘Superglue tank’” with its rechargeable sublimation chamber containing three ports for additional chemistry (superglue, water, sublimation dyes).
A computational study of the discriminative power of friction ridge patterns is conducted through: (i) assessing models of individuality including generative statistical approaches, (ii) evaluating the effect of quantity and quality in matching, e.g., how does the number and combinations of minutiae present affect individualization? and (iii) comparing live scan and latent print data of twins to the general population. Milestones achieved thus far are:

1. Several methods of friction ridge matching have been developed:
   (i) Use of discrete ridge points—which are points along ridges, away from minutiae (ridge endings and bifurcations). Ridge points, obtained by using average ridge separation as sampling resolution, are used together with minutiae in matching.
   (ii) Modeling the distributions of match/non-match scores using Gamma distributions and using likelihood ratios, instead of ROC curves, to determine the decision point.
   (iii) Use of compound minutiae—wherein the matching process takes into account the matching of nearby minutiae and global consistency in alignment.
   These approaches significantly decrease error rates than by using standard AFIS methods such as the Bozorth matcher based on using only minutiae and ROC curves.

2. Partial prints have been created for quantity-quality studies. From a set of 800 fingerprints partial fingerprints corresponding to six noise levels (with 10, 15, 20, 25, 30 and 35 minutiae) have been created. Error rates for different levels of noise are being characterized, showing the rate at which error rate decreases as the number of minutiae is increased.

3. A survey of different individuality models for fingerprints has been completed. As part of this study, a generative model of minutiae position and orientation is being created. Using such a model the probability of two fingerprints matching within a given tolerance can be accurately determined. The comparative study of individuality models will be released as a report.

4. A database of friction ridge patterns of a population of twins has been obtained and is being prepared for analysis. Some of the issues for conducting the study have been formulated, e.g., methods for evaluating friction ridge matching performance when a pair of prints are from twins and when they are from non-twins, use of zygotic information in characterizing the results, etc.
Cultivating Methods to Enhance the Quality of Aged Fingerprints Developed by Cyanoacrylate Fuming

The University of Tennessee

This project will investigate the molecular level processes that impact the superglue fuming of a latent print in order to provide fundamental information that can be utilized by forensic scientists to optimize the fuming process. It is assumed that some component of the fingerprint that resides on the ridge of the fingerprint serves as an initiator to the polymerization of the superglue to form a polymeric layer only in those spots that contain the initiator. Eccrine sweat, which makes up the fingerprint residue, has numerous components, many of which may initiate the polymerization of cyanoacrylates, including amino acids, water, and sodium lactate. This project seeks to optimize the development of fingerprints in a broad range of conditions by superglue fuming by determining the controlling molecular actors in this process.
Hand-guns are often involved in crimes and submitted to forensic laboratories for fingerprint development. Despite the advance of fingerprint development methods over the years, firearms in general, and hand-guns in particular are still difficult exhibits for fingerprint development. The fact that few identifiable latent prints are found on firearms has been discussed both in the literature and in the courts.

This project will research this phenomenon and will attempt to develop more successful methods for fingerprint development on hand-guns. Although possible reasons for this low success rate have been discussed, the phenomenon has apparently never been examined closely and systematically.

The project will involve two stages. First, the factors that affect the life, durability, and recovery of fingerprints on hand-guns will be studied. The major portion of the second stage will involve research into optimization of the cyanoacrylate method. Today, this is the method of choice for processing hand-guns.

Throughout the years, the cyanoacrylate method has been optimized in regards to development conditions; however, the cyanoacrylate used was always either ethyl or methyl. Today, there are many more types of cyanoacrylates commercially available (butyl, octyl, etc.). Just as different types of cyanoacrylate have to be adapted to the material being glued, the same may hold true for fingerprint processing. This portion of the research could aid in the development of fingerprints on hand-guns, and in addition, could very well have implications on additional types of evidence.

Four main experiments will be carried out. In the first, the endurance of fingerprints on hand-guns will be looked at. In the second, a comparison between the developing success of various types of cyanoacrylates will be studied. The third experiment will look at some of the other development methods available. The fourth experiment will examine some possible methods for “re-juvenating” prints on hand-guns.

This presentation will outline the concepts and experiments of this project. It will also present some of the interesting and important findings that arose during the literature search stage. These findings will be very beneficial in developing the final goal of the project, that of improving the method for fingerprint development on hand-guns.
A Topological Model for the Evidential Value Assessment of Partial Fingerprints: Design and Deployment

Université de Lausanne

The research project will (1) develop a new refined statistical model to assess the evidential value associated with partial fingerprints that are found at crime scenes. The model will consider level 1 features, such as general pattern; level 2 features, such as the type and the orientation of minutiae; and level 3 features, such as position of pores. The model aims at describing their spatial location relationships based on ridge arrangements within the ridge flow, hence mimicking fingerprint examiners’ topographical process for mark analysis and comparison. The developed model will thus address most weaknesses that have been attributed to previous AFIS-like statistical models that rely mostly on minutiae Cartesian coordinates, independently of the ridge flow, and (2) develop a validation procedure that will consider the effect of using level 3 features as a complement to level 2 features for the individualization process. Secondly, the overall robustness and accuracy of the model will be assessed through a validation procedure including the study of the adequacy of the datasets used in the development of the model, the simulation of forensic casework scenarios, and by comparing it to a previously developed model.

This research shall take into account the effects of pressures and distortions. The contractor’s research shall consider the results generated from any other previous professional scientific studies in this area. Any statistical analysis in this research shall wholly relate to enhancing the scientific foundation of friction ridge identification and matching as noted in recent U.S. District Court and Supreme Court decisions such as Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579 (1993); Kumho Tire Co., Ltd v. Carmichael, 526 U.S. 137 (1999); and U.S. v. Plaza, Cr. No. 98-362 (E.D. Pa). The expected deliverables shall be reports and products that summarize the statistical findings in a format that would be acceptable for publication in respected, peer-reviewed scientific journals.
Latent-Print Detection by Macro-Raman Imaging

Oak Ridge Operations Office

Fingerprints deposited on many surfaces often go undetected once latent prints age over a few hours, especially when exposed to UV radiation. The ability to develop latent fingerprints is influenced by many factors including print-type (clean/eccrine through oily/sebaceous), humidity, light, surface matrix, etc. Recent findings on the fundamental chemistry of superglue fuming, a prominent method for developing prints on non-porous surfaces, revealed methods capable of enhancing the ability to develop latent fingerprints that would otherwise go undetected. This enhancement, however, was not effective on fingerprints exposed to UV radiation from sun or fluorescent lighting, especially on surfaces containing iron (III). In addition, the enhancement method is complex and not easily amenable to field applications. Thus, a real need exists to efficiently and effectively detect latent fingerprints on all surfaces regardless of the print type or environmental-exposure factors. To accomplish this goal, further study is needed to better characterize constituents and associated degradation products originating from fingerprint secretions deposited on a range of matrices. Through an understanding of time-related changes in fingerprint components, discrimination between fingerprint constituents and the deposition surface is expected to facilitate the development of enhanced friction ridge visualization methods.

In this current research initiative sponsored by NIJ, simplistic methods that increase the detection sensitivity for macro-Raman imaging have been targeted to address short-falls in fingerprint detection. With the type of discriminatory power afforded by surface-enhanced Raman substrates, we expect an increase in the average print area and quality, as well as an approach to differentiate between fresh and aged prints. In order to exploit the anticipated enhancements for Raman detection of latent fingerprints, researchers from the Oak Ridge National Laboratory (ORNL) are teaming with experts in chemical imaging – ChemImage Corporation. The overall goal of this project is to employ methods to enhance Raman-based latent-print visualization and utilize the enhancement methods to modify the patented ChemImage system for field applications. Such a system is expected to enhance the efficiency and quality of latent-print detection in cases involving assault, murder, etc. Under this Phase I initiative, ORNL is working with ChemImage to conduct the basic research needed to design a macro-Raman chemical imaging methodology capable of accomplishing the stated objective. Research findings to date in the areas of fingerprint-component and degradation product identification, SERS-Raman materials and optical characteristics (when in contact with fingerprint constituents), and a conceptual macro-Raman imaging system will be presented during the review session.
To date, the body of scientific knowledge does not provide adequate understanding regarding the growth pattern of fingerprints to enable the positive identification of children over a period of several years. While governments around the world are considering national identification policies, scientists are still unclear as to the spatial orientation of minutiae changes with maturation. Ultra-Scan Corporation is currently undergoing this 5-year study examining the dermatoglyphic growth patterns in children through adolescence, for the purpose of identifying any commonality of fingerprint pattern growth within demographic traits, as well as developing a predictive model of change for fingerprint patterns.

Ultra-Scan anticipates that the establishment of a 2-way fingerprint predictive growth model will assist latent examiners in the identification of young children, improve the accuracy of automated latent search engines, and expand the scientific body of knowledge regarding fingerprint patterns. This discussion will present information regarding Ultra-Scan’s research design, 5-year study methodology, and expected results.
West Virginia University (WVU) is working to provide the forensic community with a more comprehensive understanding of the empirical basis for friction ridge impression evidence. This project aims at providing the forensic community with a framework to address the requisite conditions and effectiveness of using a combination of Level II and Level III details for comparison between latent prints collected in a crime scene and very high quality reference prints. The study will use three distinct sets of reference fingerprints collected from different fingerprint sensor technologies. Besides ink rolled fingerprints and prints from a livescan unit, a dedicated optoelectronic system (from TBS) with five cameras and an array of 59 LED’s will be used for the first time to capture fine friction ridge Level III sweat pore details. The scientific study will investigate the lower bounds for establishing valid correspondence between the detailed reference print and the latent print with varying quality and quantity. In addition to the minutiae-based matching score obtained from the AFIS, an algorithm for pore-based Level III matching score will be developed. The two scores will be combined to quantitatively evaluate the empirical basis of friction ridges for forensic applications using Level II and Level III features.

The research methodology uses an AFIS to establish a baseline for understanding the empirical underpinnings of friction ridge evidence. The large sample size of over 280,000 tenprints and the potential number of comparisons involved precludes extensive human examiner involvement. By focusing on the use of AFIS to generate the data for analysis, we employ existing methods in operational laboratories, reduce costs, and improve timeliness for this project.
The presentation summarizes and updates a joint project between the Scientific Working Group on Friction Ridge Analysis, Study, and Technology (SWGFAST), and the West Virginia University Forensic Science Initiative to produce a single authoritative Sourcebook which describes fingerprint history, morphology, methodology, guidelines, latent print procedures, AFIS, legal admissibility, and standard terminology. A professional editor will manage a team of authors and student research assistants to compile source materials into a single publication. Experts in specific fields of the fingerprint science will draft individual chapters supported by footnotes and bibliographical references gathered by research assistants. It will be distributed to universities, law enforcement agencies, forensic laboratories, and to individual practitioners to standardize fingerprint methodology and terminology.
Fast-Capture of Finger/Palm Prints Program
Fast-Capture of Finger/Palm Prints

- Capture 10 rolled-equivalent fingerprints in ≤ 15 seconds and both palms in ≤ 1 minute or less
  - Capture full set; match against subset
    (for access control, forensics, etc.)
  - Meet or exceed all FBI and NIST image specifications

- Requirements developed by interagency working group, including DOJ, DOD, DHS, State Department

- Five projects using four approaches:
  - A U-shaped ASIC-based flexible sensor that each finger fits into
  - Two camera-based systems that take multiple high-resolution flash images of the fingers and palms
  - A circular optical mirror system that the fingers are drawn across to create an image

- Working devices expected within 18 - 24 months
The Office of Legal Policy initiated the effort in January 2004 based on the perceived need. The DAG sent letters in March 2004 to the Departments of Homeland Security, Defense, and State requesting their participation. Resulting solicitation is a highly cooperative, joint effort of the Justice components (NIJ, FBI, DEA, OLP & JMD) and the DHS, DoD, & DOS. Requirements represent a major step forward in finger and palm print capture technology:

- Capture of 10 rolled-equivalent fingerprints in 15 seconds or less;
- Capture of both palms in 1 minute or less;
- Meets or exceeds FBI & NIST specifications;
- Reduces failure-to-enroll rates;
- Produces a working device suitable for independent test in 18 months; and is
- Affordable, rugged, portable, relatively unobtrusive in size, and deployable in the near future.
Three technology approaches are being pursued in four separate projects:

- A U-shaped flexible sensor that conforms to the shape of each finger;
- Two camera-based systems that take multiple high-resolution flash images of the fingers and palms; and
- A circular optical mirror system that the fingers are drawn across creating an image.

Each project will produce working devices within 18 months to 2 years that are suitable for independent performance testing.

- Total program budget is $8 Million including evaluation of resulting devices.
- Funds to initiate this effort have been provided by the FBI/CJIS Division, Justice Management Division, and the Department of Homeland Security.
- NIJ will fund an independent technology assessment against NIST & FBI image and performance standards.
Crossmatch/Smiths Detection - Flexible Foil Contact Sensor

- **Project Description**: Development of a flexible foil contact sensor, a 2-dimensional sensor array on a polymer plastic, to quickly capture the equivalent of a rolled fingerprint.

- **Deliverables & Schedule**:
  - Prototype device

- **Partners**: FBI/CJIS, JMD IDENT/IAFIS, DHS

- **Performer**: Crossmatch Technologies

- **POC**: Jack Carver/Uwe Richter

Concept for 7”x6” Flexible Palm Sensor

1.6 x 1.6-inch
500 ppi
Sensor
TBS North America - Segment Imaging™

- **Project Description:** Development of the Segment Imaging™, a touchless, optoelectronic finger imaging system. The system will capture the 10 rolled equivalent fingerprints within 15 seconds.
- **Deliverables & Schedule:**
  - Single-finger Prototype in 9 months
  - Prototype Hand Device in 18 months
- **Partners:** FBI/CJIS, JMD IDENT/IAFIS, DHS
- **Performer:** TBS North America
- **POC:** Bill Long

Prototype Single-finger Capture Device delivered to NIST in June 2006

Prototype Single-finger Image from June device

Prototype Full-hand Capture device to be delivered in April 2007
Carnegie Mellon University – Hand Shot ID

- **Project Description**: Development of the Hand Shot ID system which constructs a visual 3-dimensional model of both hands by stitching images from multiple cameras together, forming a complete 3-D model.
- **Deliverables**: Prototype Device
- **Partners**: FBI/CJIS, JMD IDENT/IAFIS, DHS
- **RDT&E Activity**: Phase 3 - Implement NIJ R&D
- **Performer**: Latanya Sweeney - PI

Capture and Processing to Ink-like Image
Note that depth of focus includes finger surfaces and calibration patterns.
Fast Capture Initiative General Comments

• Each project will produce working devices in 18 months to 2 years that are suitable for independent performance testing.

• Total Initiative budget is $7 Million including evaluation of resulting devices.

• Funds to initiate the first year of each effort has been provided by the FBI/CJIS Division, Justice Management Division, Department of Homeland Security, and the Department of Defense.

• NIJ will fund an independent technology assessment against NIST & FBI image and performance standards.

“If successful, this initiative will leave a legacy for law enforcement.”

The Honorable James B. Comey
Deputy Attorney General
January 25, 2005