



NIST Ballistics Toolmark Research Database



Xiaoyu Alan Zheng, Johannes Soons, Robert Thompson

National Institute of Standards and Technology

alan.zheng@nist.gov

(301) 975-4095

FTAP

Forensic Toolmark Analysis Project



FORENSICS @ NIST

#NISTForensics

Disclaimer

Certain commercial equipment, instruments, or materials are identified in this presentation to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology or the National Institute of Justice, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

FTAP

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Criticism on Subjectivity

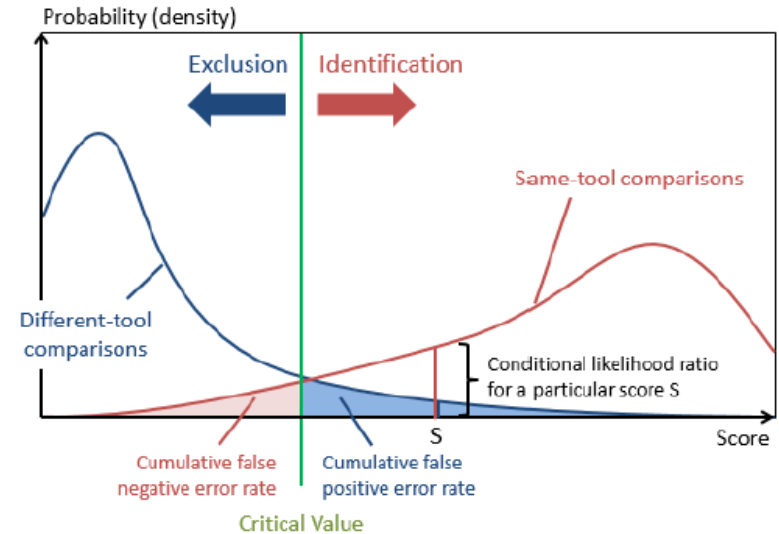
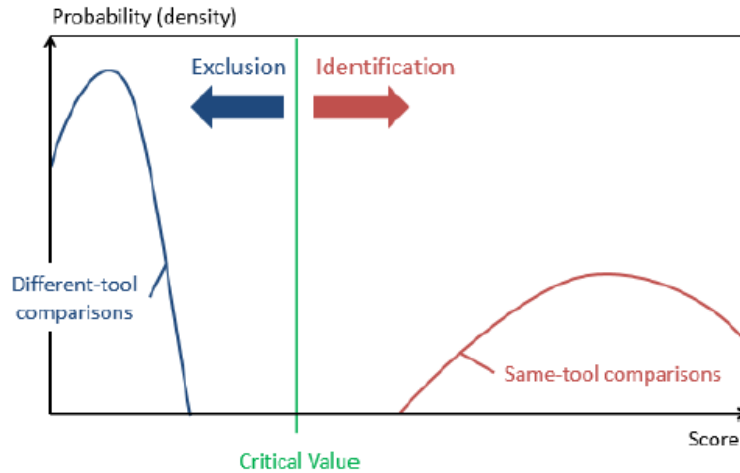
- Pattern evidence have come under scrutiny in recent years due to the subjective nature of the conclusions.
- NAS 2009 “..the decision of the toolmark examiner remains a subjective decision based on unarticulated standards and no statistical foundation for estimation of error rates.”

Solutions

Instrument suppliers, academia, and government laboratories are addressing these challenges through two approaches

- Improvement of the quality of ballistics imaging data. Namely through direct traceable measurements of the toolmark topography.
- Development of objective mathematical criteria for the similarity of two samples with associated confidence limits and algorithms.

Statistical Framework



- In order to accurately model these distributions, large characteristic populations of diverse firearms are required.
- It is not economically feasible for any one entity to generate the data required. It will require a collective effort.

Objective

- Open-access research database of bullet and cartridge case toolmark data consisting of reflectance microscopy images and three dimensional surface topography data.

Motivation:

- Foster development and validation of methods, metrics, and uncertainty estimates for objective ballistics identification.
- Improve scientific knowledge base on the similarity of marks from different firearms and the variability of marks from the same firearm.
- Ease transition to application of 3D surface topography data.

Crowdsourcing Data



To achieve a truly diverse and representative database, NIST cannot do this alone. It requires the help of the firearms forensic community

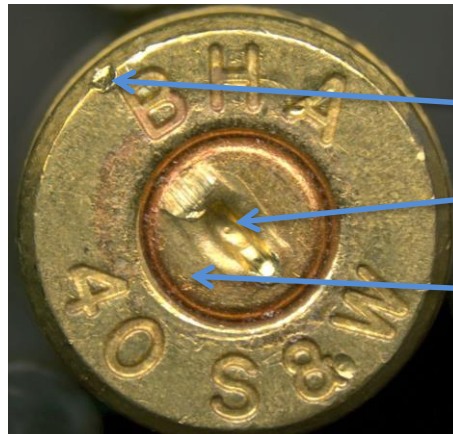
Specimens and regions of interest

- Bullets (pristine): land engraving



Areas “engraved” by barrel lands

- Cartridge cases: breech face and firing pin impressions



Ejector mark

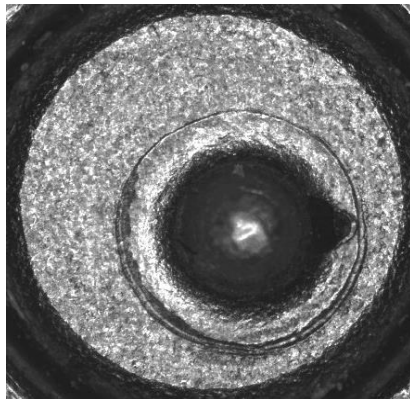
Firing pin impression

Breech face impression

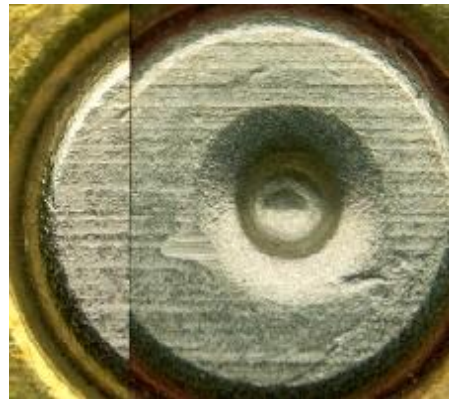
Source: AFTE

Studies and test fires of interest

- Consecutively manufactured firearm components.
- Same firearm firing many rounds of ammunition (persistence/decay).
- Same firearm firing different brands of ammunition (pre-existing marks).
- Firearms known to present identification challenges.
- Firearms representing the major class/subclass characteristics.

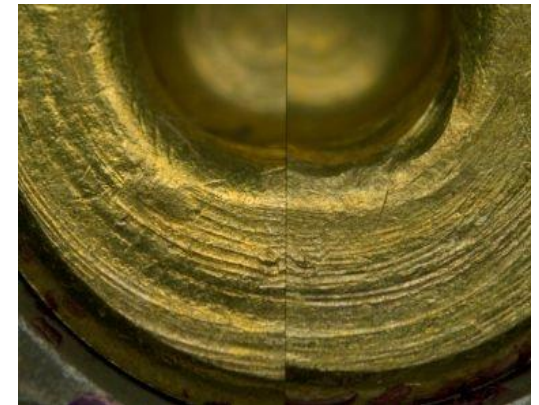


Random pattern of
peaks and valleys



Source: AFTE

Parallel lines



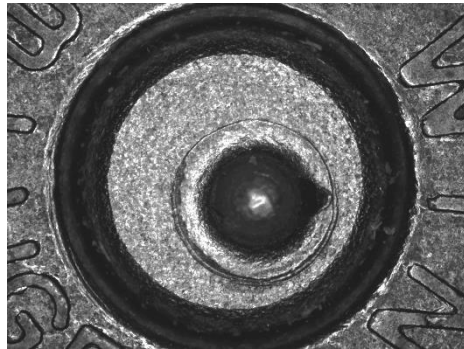
Source: AFTE

Concentric circles

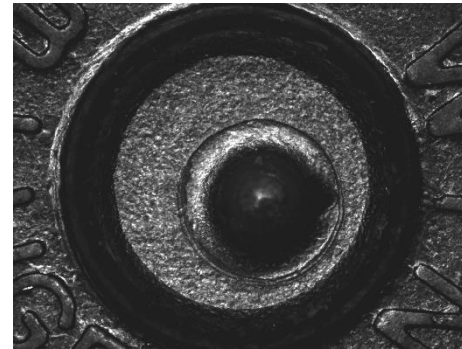
NIST measurements: reflectance microscopy

Forensic comparison Microscope

- Breech face impression (2X objective, 2.53 μm mean pixel size).



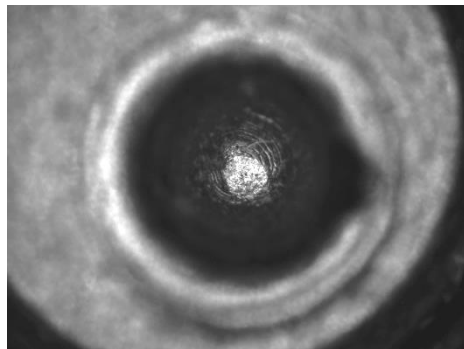
Ring light illumination



6 o'clock side light illumination

1944 pixels
or 4.92 mm

- Firing pin impression (4X objective, 1.265 μm mean pixel size)



Ring light illumination

1944 pixels
or 2.46 mm



Source: Leica

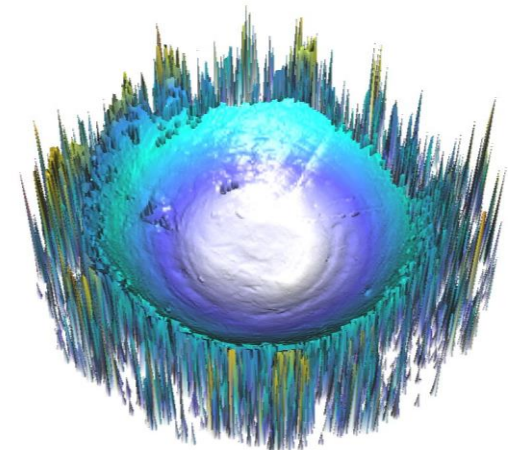
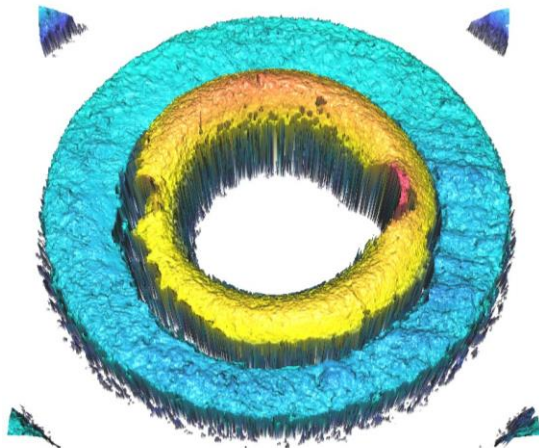
NIST measurements: 3D surface topography

Disc scanning confocal microscope

- Bullet land engraving (20X objective, 1.563 μm mean pixel size).

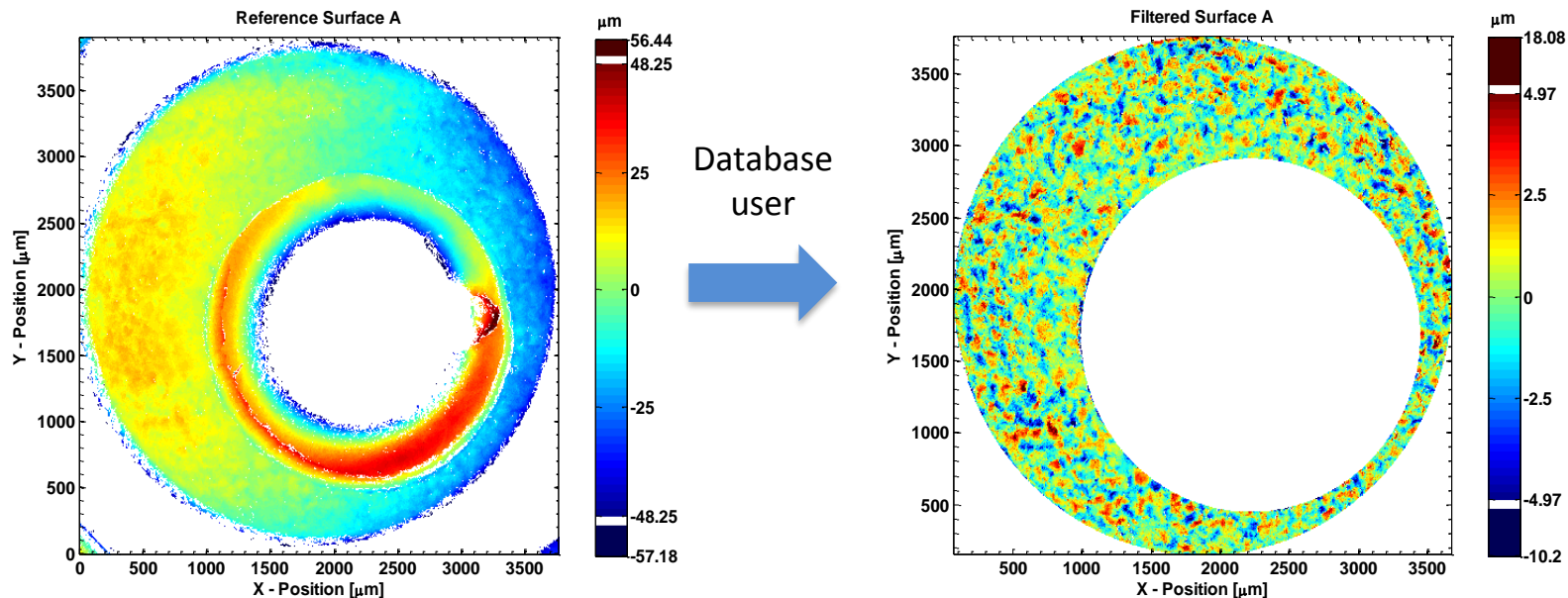


- Breach face impression (10X objective, 3.125 μm mean pixel size)
- Firing pin impression (20X objective, 1.563 μm mean pixel size)



Data transfer (measurement data)

Measurement data is provided as raw data (no trimming, leveling, form removal, filtering etc.):



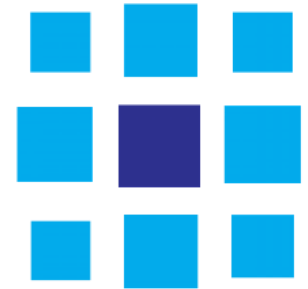
- Reflectance microscopy images in lossless TIFF format
- 3D topography data in X3P format (XML 3D surface Profile)

Standard File Exchange Format – X3P

- **XML 3D Surface Profile (X3P)** is an efficient, extensible, data format for storing surface topographies (ISO 25178-72).
- The format is being adopted for firearm and toolmark data by OSAC and OpenFMC (instrument manufacturers, academia, and government labs).

Each file contains 3 key records:

- 1) Header, data types, and axis definition
- 2) Meta data regarding the instrument and user
- 3) Profile data (x, y, z).

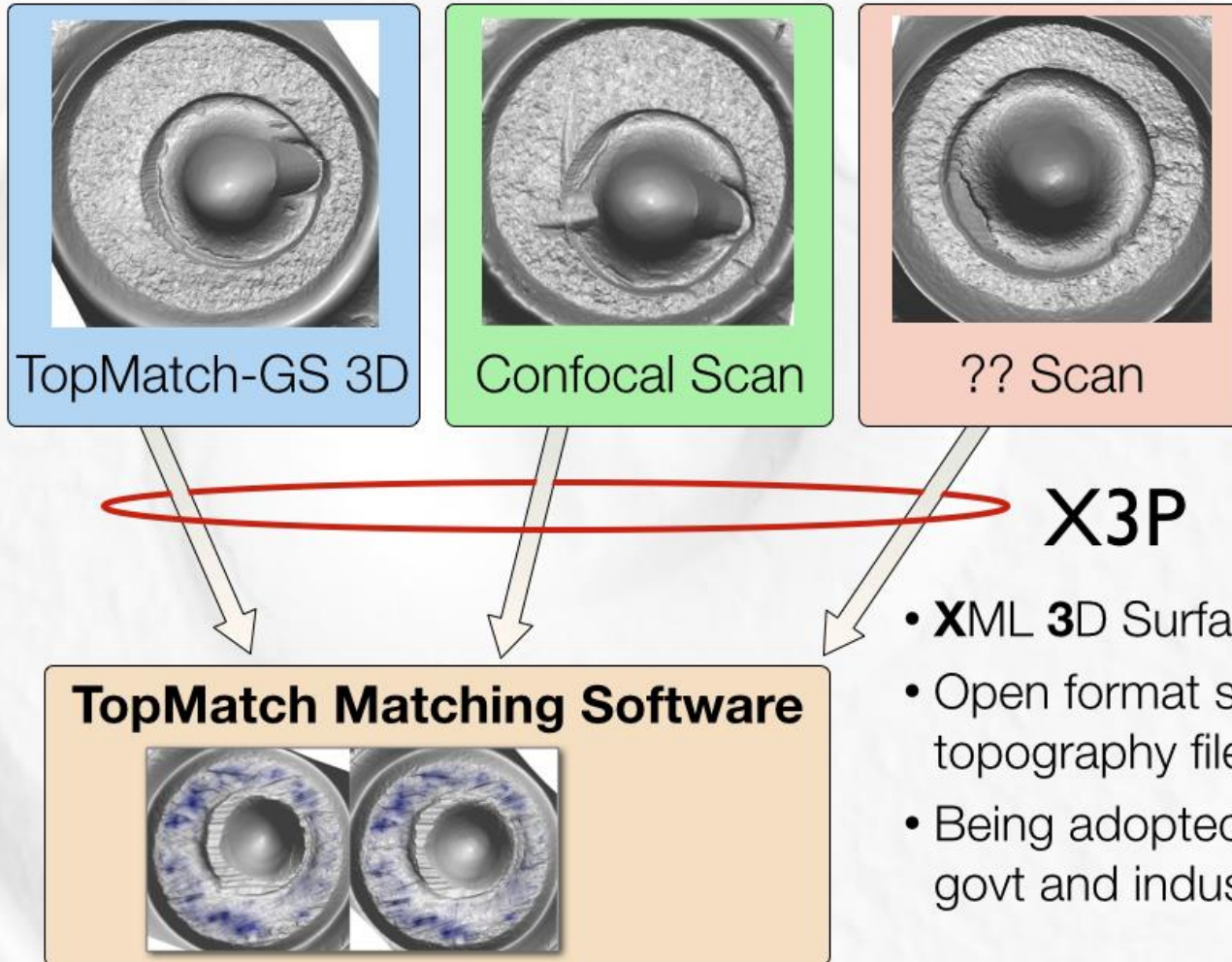


X3P

- The format is extensible. Extra, user-defined, data can be attached (e.g., firearm, ammunition, and measurement conditions).
- Open-source read/write functions, visualization software, and converters are available.



Cross-Modality Matching



Results from Cross-Modality Study

- Cadre research successfully imported NIST confocal data into their correlation software and was able to correctly identify all test fires.
- The same accuracy was achieved when comparing Cadre data vs NIST confocal data.
- This test demonstrates that X3P is a suitable format for interoperability between different instruments.
- Additional tests have been conducted between NIST and Cadre Research, FBI, John Jay College, and the Nederland Forensic Institute.
 - All exchanged data files have been successfully opened and verified.

OpenFMC Membership

- Anyone interested in being a part of the working group can join. Please contact: alan.zheng@nist.gov
- Current Members:
 - NIST
 - Cadre Research
 - Alicona
 - Nanofocus
 - Leica
 - Zeiss
 - Forensic Technologies
 - Sensofar
 - Leeds
 - NFI
 - John Jay College
 - Oakland Police Department

Data transfer (meta data)

- Data is organized into toolmark studies
- Each study dataset has a spreadsheet with meta data.

Study:

- Name
- Creator
- Description
- Literature reference
- Has consecutive?
- Has persistence?
- Has different ammo?

Firearm:

- IdNumber
- Brand
- Model
- Caliber
- Firing pin class
- Breech face class
- Number of lands
- Twist direction

Bullet:

- IdNumber
- Brand
- Cartridge designation
- Lot number
- Nominal caliber
- Weight
- Surface Material
- Firing sequence
- Comments

Cartridge Case:

- IdNumber
- Brand
- Cartridge designation
- Lot number
- Nominal caliber
- Primer surface
- Firing sequence
- Comments

Bullet Measurement:

- File name
- Creator
- Measurement type
- Measurand
- Region of interest
- LEA or GEA number
- Instrument brand
- Instrument model
- Lateral resolution
- Vertical resolution
- Lighting type
- Objective magnification
- Objective NA
- Comments

Cartridge case Measurement:

- File name
- Creator
- Measurement type
- Measurand
- Has breech face?
- Has firing pin?
- Has ejector mark?
- Has aperture shear?
- Instrument brand
- Instrument model
- Lateral resolution
- Vertical resolution
- Lighting type
- Objective magnification
- Objective NA
- Comments



NIST Ballistics Toolmark Research Database

Welcome to NIST Ballistics Toolmark Research Database

The **NIST Ballistics Toolmark Research Database (NBTRD)** is an open-access research database of bullet and cartridge case toolmark data. The development of the database is sponsored by the U.S. Department of Justice's National Institute of Justice. The database is being developed to:

- foster the development and validation of measurement methods, algorithms, metrics, and quantitative confidence limits for objective firearm identification
- improve the scientific knowledge base on the similarity of marks from different firearms and the variability of marks from the same firearm, and
- ease the transition to the application of three-dimensional surface topography data in firearms identification.

The database contains traditional reflectance microscopy images and three-dimensional surface topography data acquired by NIST or submitted by database users. The goal is a collection of data sets that:

1. represents the large variety of ballistic toolmarks encountered by forensic examiners, and
2. represents challenging identification scenarios, such as those posed by consecutively manufactured firearm components.

A user account is only required if you are interested in UPLOADING data. To DOWNLOAD data, please click [Search & Download](#).

Register a user and log in

- Click [Register](#) to complete a new user registration.
- Click [Log in](#) to log into the system using user name and password.

 Updates/News

- [NIST 3D Ballistics Research Database Goes Live \(7/7/2016\)](#) – New forensic science database will provide a statistical foundation for more reliably linking bullets to the guns that fired them.
- [Forensic MagazineLink \(7/11/2016\)](#) – An article detailing the NIST Ballistics Toolmark Research Database.
- [GCN MagazineLink \(7/12/2016\)](#) – An article detailing the NIST Ballistics Toolmark Research Database.
- [2016 GCN Dig IT awardsLink \(8/18/16\)](#) – The NBTRD has been named as one of the six finalists under "Big data, analytics, and visualization".

NBTRD Home

Register Log in Search & Download Data Format Acknowledgements

Search and Download

Study

Persistence

-- Select --

Consecutive

-- Select --

Firearm

Firearm Brand

-- Select --

Firing Pin Class

-- Select --

Of Lands

-- Select --

Caliber

-- Select --

Breech Face Class

-- Select --

Twist Direction

-- Select --

Bullet and/or Cartridge

Nominal Caliber

-- Select --

NIST Measurement

-- Select --

Measurand

-- Select --

Measurement Type

-- Select --

View Cartridges

View Bullets

Bullet

Brand

-- Select --

Region of Interest

-- Select --

Cartridge

Brand

-- Select --

Breech Face

-- Select --

Ejector Mark

-- Select --

Firing Pin

-- Select --

Aperture Shear

-- Select --

Clear Filter

Search

NBTRD Home

[Register](#)[Log in](#)[Search & Download](#)[Data Format](#)[Acknowledgements](#)

Data Format and Meta Data

Measurement data is provided as raw data. Depending on the nature of the firearm identification approach, users may have to apply data processing operations such as data trimming, outlier rejection, edge detection, leveling, form removal, and filtering.

Reflectance microscopy images are provided in lossless .PNG format. 3D topography data are provided in .X3P format (XML 3D surface Profile):

- Defined in ISO working draft 25178-72 for exchange of surface texture data
- Open source read/write functions (C++ and Matlab™) and converters
- Enables (custom) meta data defining measurement parameters
- NIST is collaborating with industry partners for application to 3D forensic surface topography data

Each X3P file contains four records:

- Record 1: Header, data types, and axes definition
- Record 2: Meta data regarding the instrument and user
- Record 3: Profile Data (x, y, z)
- Record 4: Checksum of the xml-document

For more information regarding the X3P file format, please visit: <http://open-gps.sourceforge.net/>

As part of the [Open Forensic Metrology Consortium \(OpenFMC\)](#), [Cadre Forensics](#) and [John Jay College of Criminal Justice](#) provide software to read and write X3P into both Matlab™ and C++. OpenFMC is an informal collaboration of industry, academic, and government research laboratories.

- If you would like to download the Matlab™ x3ptoolbox, please visit: <https://github.com/OpenFMC/x3p/tree/master/src/MATLAB>
- If you would like to download C++ utilities, please visit: <https://github.com/OpenFMC/x3p>
- If you would like to download R utilities, please visit: <https://github.com/npetraco/x3pr>

Each measurement data file contained in the database will have a set of meta data describing the study, firearm, bullet/cartridge case, and measurement parameters. The meta data organization tree is shown below:

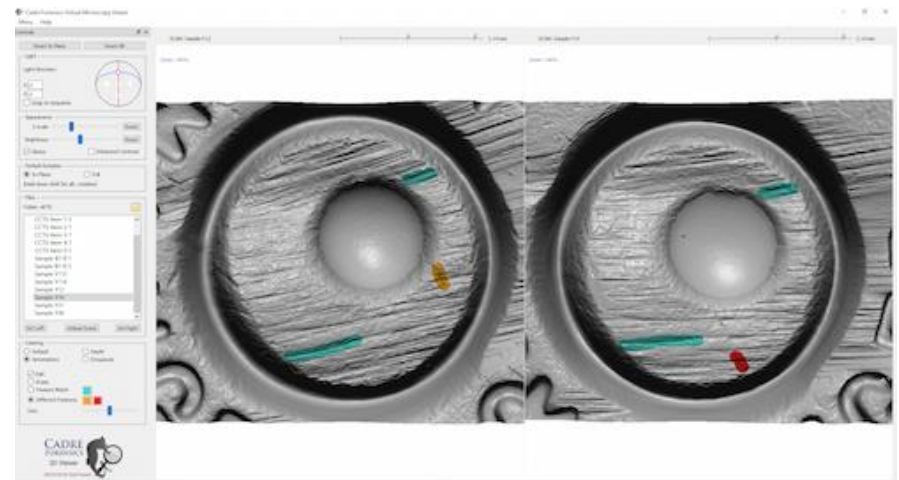
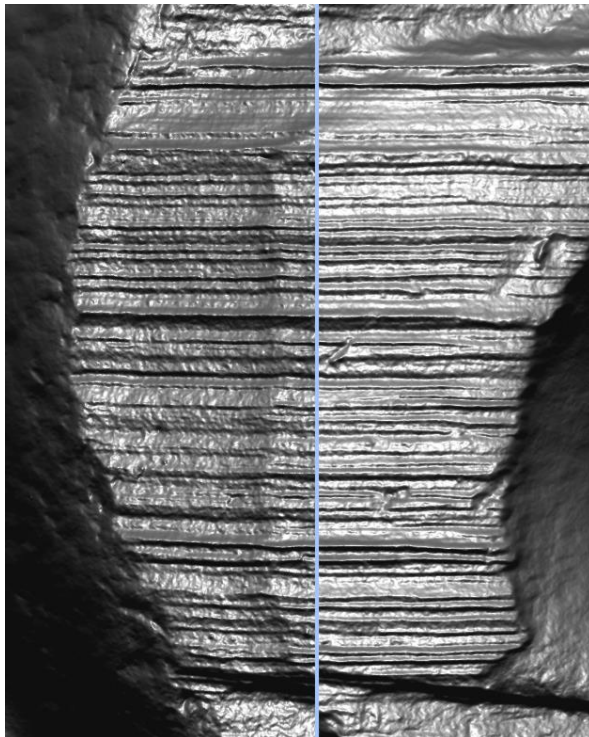


X3P Viewer

To download a free X3P viewer, please head to <http://www.openfmc.org>. At the bottom of the page, click on "Request Viewer".

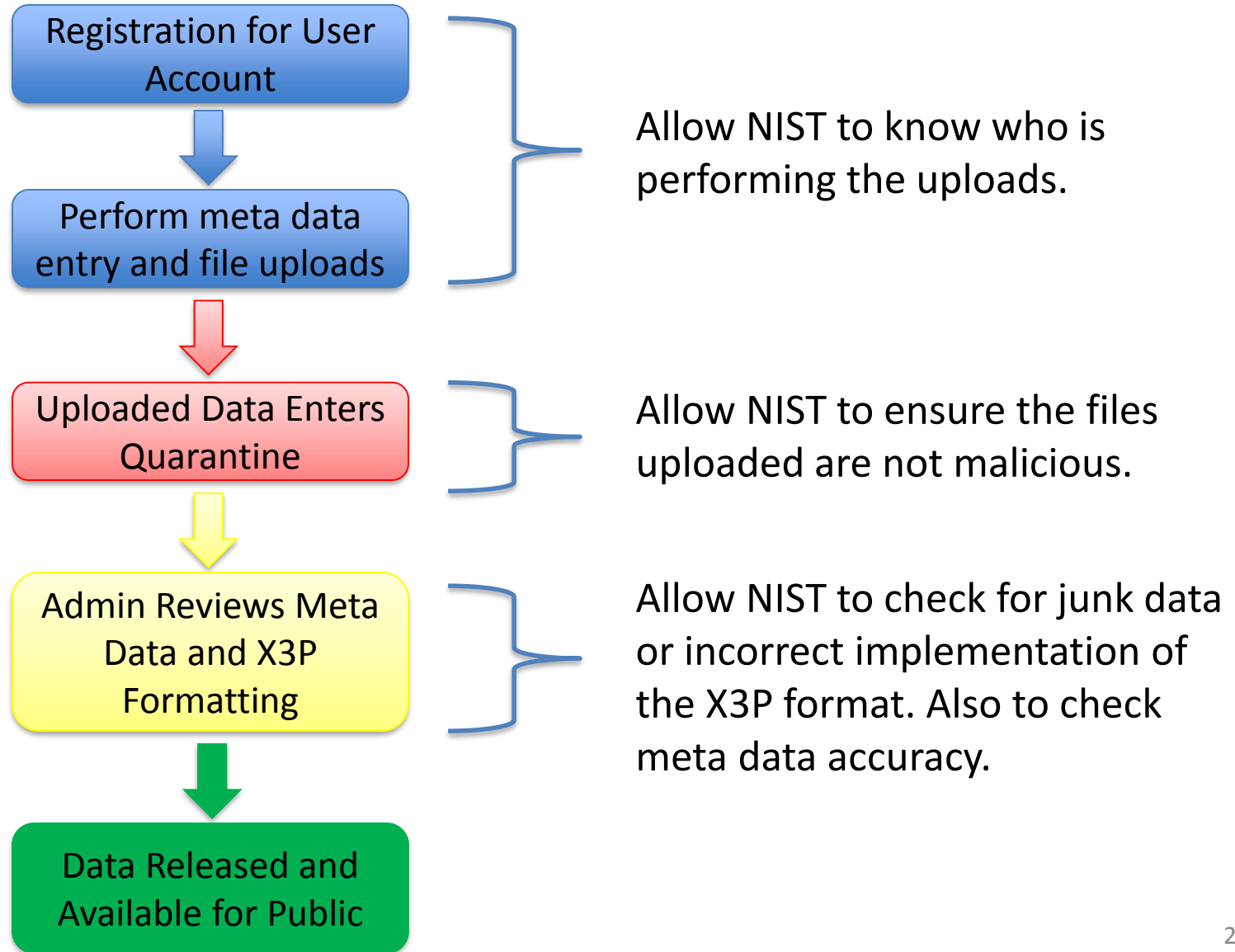
Applications of the Data

- Algorithm Development
- Statistical Analysis
- Training
- Virtual Microscopy



<http://www.cadreforensics.com/viewer.html>

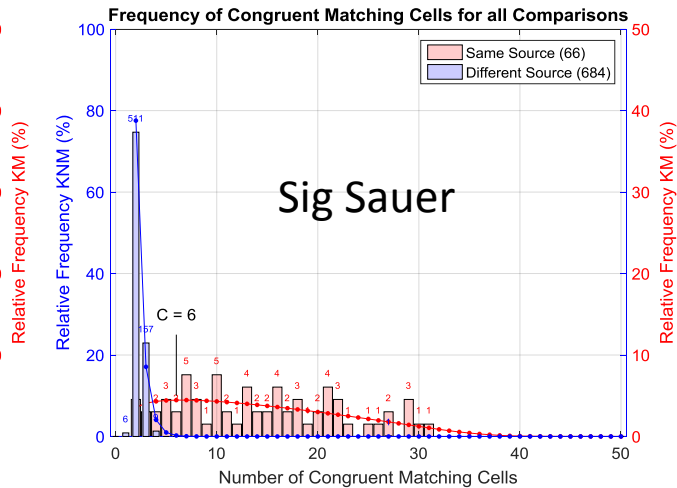
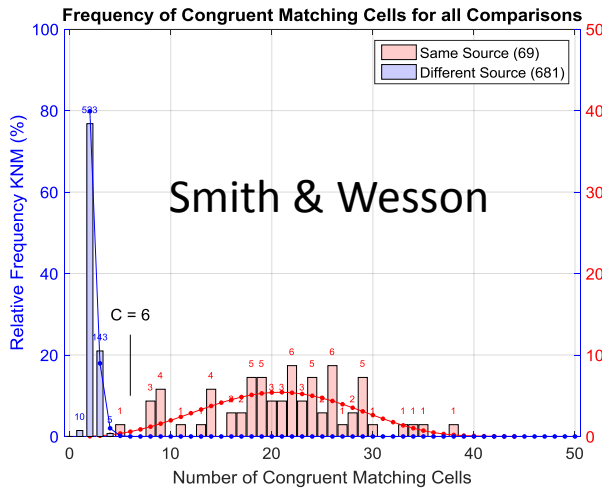
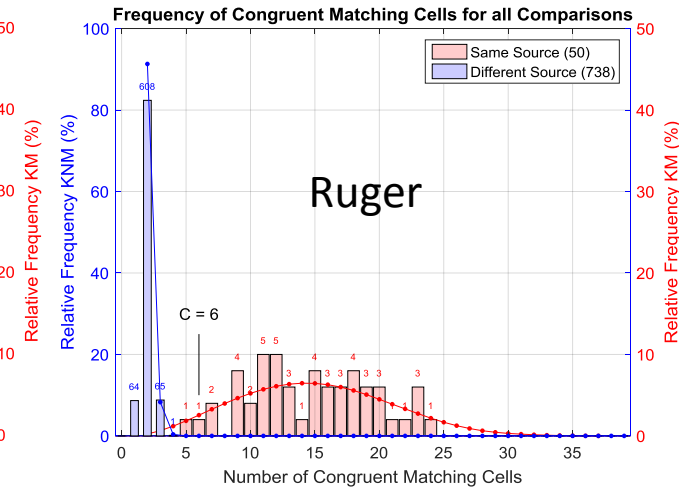
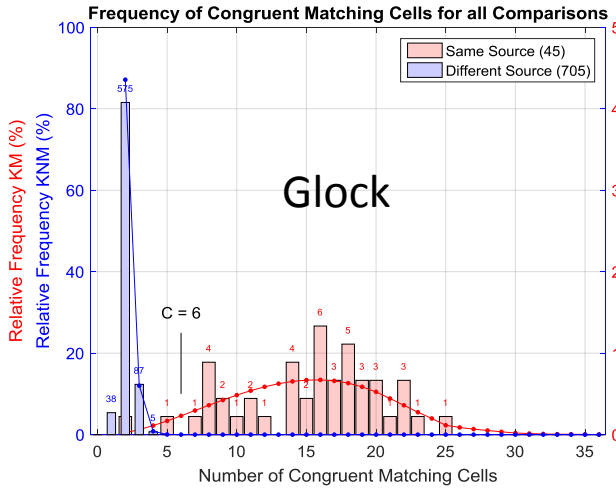
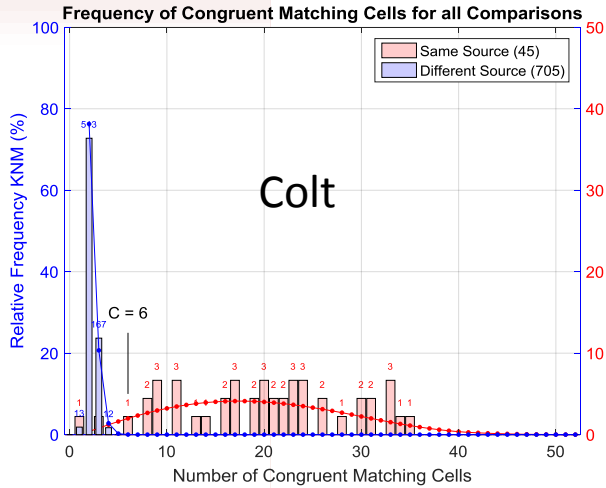
Upload Process and Quality Checks



Future of the NBTRD

- NIST will continue to curate and manage the database
- NIST will continue to market, collect, measure, and enter in new sets of test fires for added diversity
- 2017 NIJ funding
 - Administrative reporting functions
 - Improve upload process efficiency
 - Improve search results with advanced filtering and sorting functionality
 - Ensure data accessibility and integrity
 - Entrance of forensic laboratory reference collections

NIJ Research: Initial Population study



 Acknowledgements

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Sushama Singh, Cerasela Constantin, Olena Stupak, Amber Smoot, Robert Commarota and Jeff Chu

 Collaborators



Thanks for your attention!

Questions?

alan.zheng@nist.gov

johannes.soons@nist.gov

robert.m.thompson@nist.gov

