

Firearms and Toolmark Analysis

Presented by: Dr. Heike Hofmann

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forensicstats.org



Research Area Objectives

Currently established comparison standard:

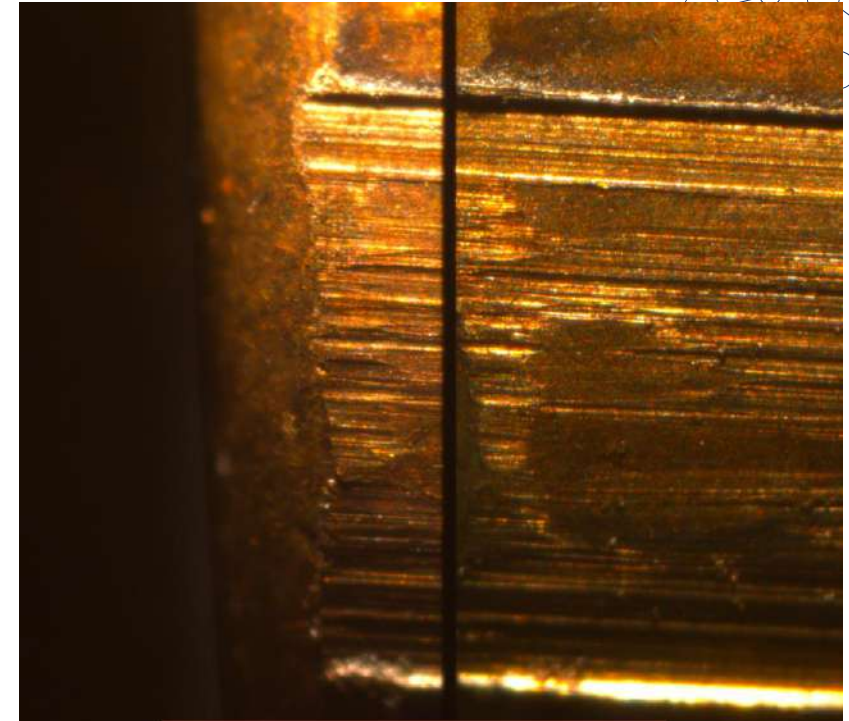
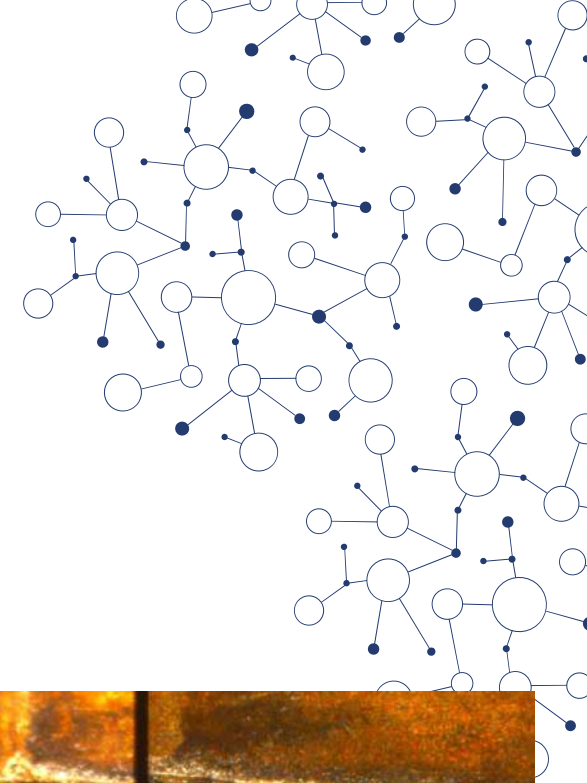
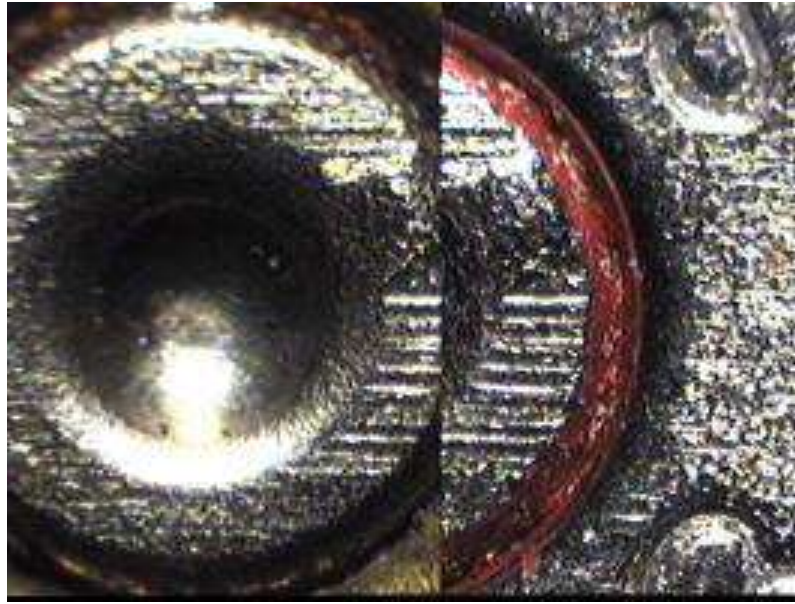
**AFTE Theory of
identification**

1. examine class characteristics
2. use microscopic analysis to assess detailed features

Identified Problems:

1. establishing error rates of identification process
2. subclass characteristics (determined by proficiency tests in Europe) are a key risk factor for false identifications.

CSAFE 1.0 Accomplishments

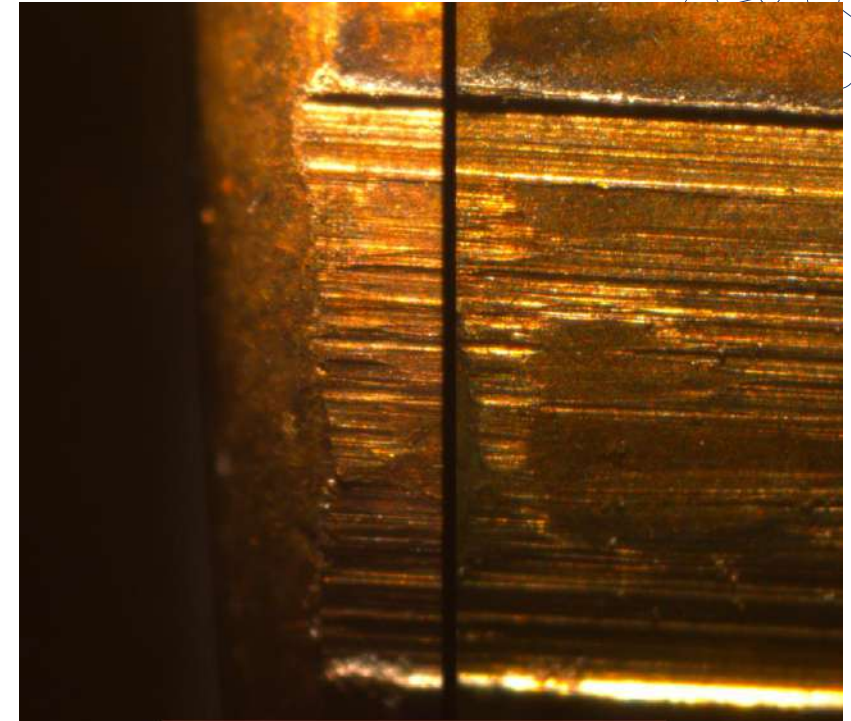
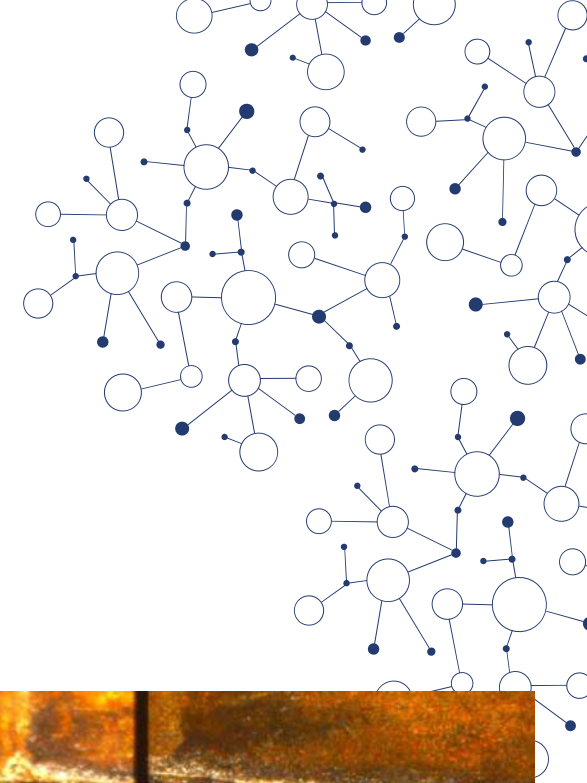
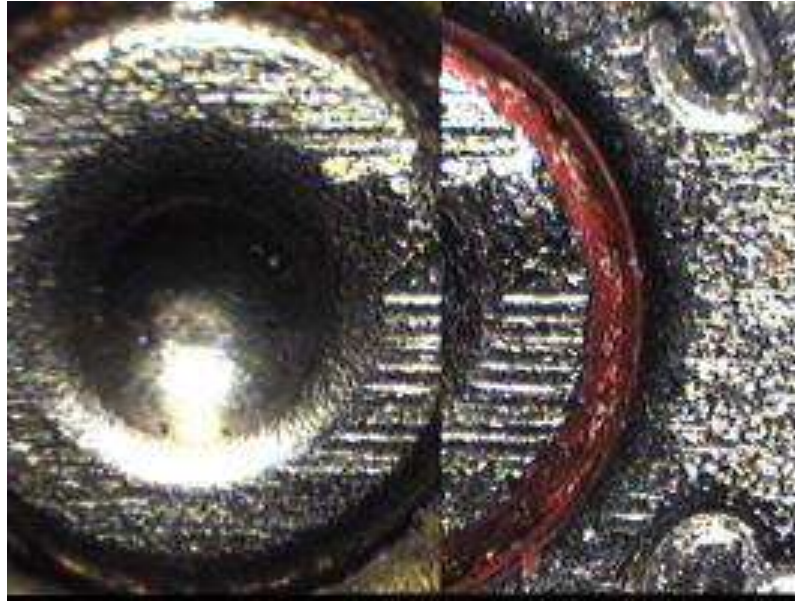


The graphic features a dark blue rectangular header with the text 'CSAFE 1.0 Accomplishments' in white. To the left of the header, there is a red square and a smaller black square, partially overlapping the blue area.

CSAFE 1.0 Accomplishments

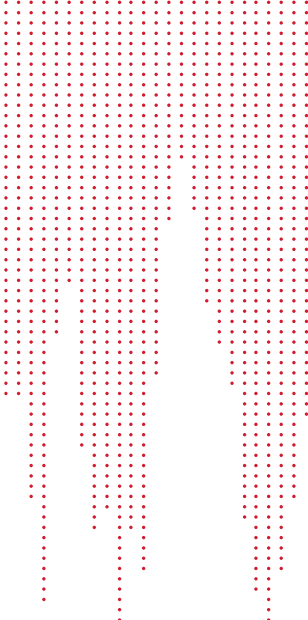
1. Two automated **matching algorithms**:
bullets (Hare et al., 2017a; Hare et al., 2017b)
cartridge cases (Tai and Eddy, 2017)
2. **Open source** algorithms: *cartridge3D*, *x3ptools*, *bulletxtrctr*
3. **Open data**: 3d topographic high-resolution scans of bullet lands (~25,000) and cartridge cases (~2,000), mostly uploaded to the NIST Ballistics Toolmark Research Database Evaluation (NBTRD).

CSAFE 2.0 Objectives





CSAFE 2.0 Projects and Lead Investigators



F&T I- Statistical and Algorithmic Approaches to Matching Bullets and Cartridges
Lead PI: Heike Hofmann, ISU

F&T II- Subclass Characterization and Analysis of Firearms
Lead PI: Keith Morris, WVU

F&T IV- Evaluating Foundational Validity of Toolmark Analysis
Lead PI: Maria Cuellar, UPenn

F&T I Statistical and Algorithmic Approaches to Matching Bullets and Cartridge Cases

Proposed Activities:

- Expand and refine matching algorithm: nontraditional rifling, new features based on image
- Quantify factors affecting matching performance: combination of firearm/ammunition, quantitatively assess quality of scans.
- Work with firearms examiners and crime labs to extend use of matching algorithms to labs

Potential Impact:

- Providing objective quantitative assessments that examiners can use during testimony
- Providing empirical support for the validity of firearms and toolmarks evaluation through objective algorithmic assessments
- Working with examiners to develop community confidence and trust in algorithmic results

F&T II Subclass characterization and analysis of firearms

Proposed Activities:

- Characterization of the manufacturing processes and breech faces
- Collaborate with firearm examiners to identify areas of subclass on all breech faces and test fires
- Collection of reference collections from five forensic laboratories
- Automated comparison using NIST congruent matching cells (CMC) algorithm with and without subclass characteristics present
- Reference collection of Contender G2 breech faces
- Creation of subclass markup GUI

Potential Impact:

- Test sets can be created from test fires (both with digital scans and double-castings)
- Examiner accuracy testing of identifying subclass characteristics
- Performance of NIST CMC algorithm with subclass present

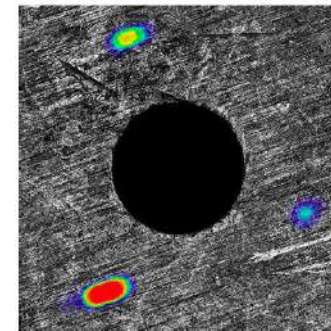


Figure 7: Example heatmap of subclass characteristics. Refer to the electronic version for color.

F&T IV Evaluating Foundational Validity of Toolmark Analysis

Proposed Activities:

- 1. Database:** Create a database of high-quality toolmark images, both 2D and 3D, using a factorial design, based on NBIDE firearms database.
- 2. Algorithm:** Develop an algorithm to determine a score-based likelihood ratio.
- 3. Validation:** Validate algorithm by testing its external validity.

Potential Impact:

- **Start with simplest case to make progress in difficult field** of toolmark analysis, which has many types of tools and degrees of freedom.
- **Develop standard statistical methods** for the analysis and comparison of toolmarks.
- **Expand the capacity** of federal, state, and local labs to deal with toolmark analysis.

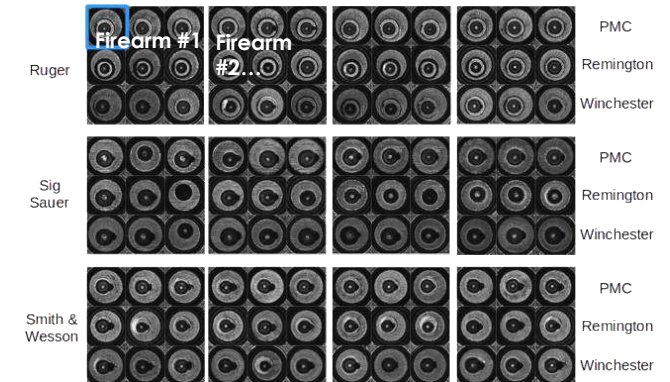
Create new database of toolmarks (start in 2D, then 3D)

NBIDE:

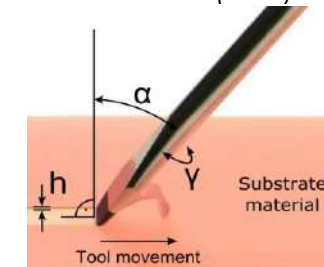
- Firearm brand
- Firearm # (of same brand)
- Ammunition brand
- Iteration per firearm/ammo combination
Iteration #1...

3D) Toolmarks:

- Screwdriver brand
- Screwdriver # (of same brand)
- Angle, surface material (soft to hard), striation vs. imprint, etc.
- Iterations per angle/surface/etc. combination



Many degrees of freedom in screwdriver mark
Baiker et al. (2016).



Screwdriver striation (L) and impression marks (R).
Petraco (2011).



Where we would need help from you!

- Forensic examiners community:
 - Standard operating procedures for assessing firearm and toolmark evidence of labs
 - Test fires of (some of) the reference collections – format needs to be determined, but ideally we would like 4 test fires for each firearm/ammunition combo
 - AFTE studies (past and on-going): we would be excited to get materials for 3d imaging!
- Forensic analysts:
 - Help us in running (proprietary) algorithms on publicly available data and make results available