Firearms and Toolmark Analysis

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csafe
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# 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
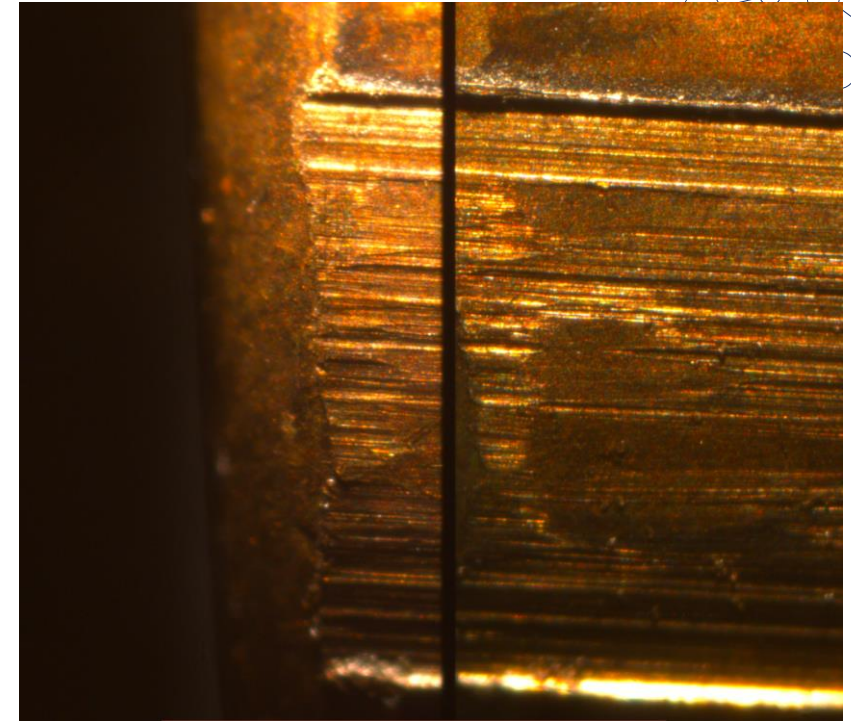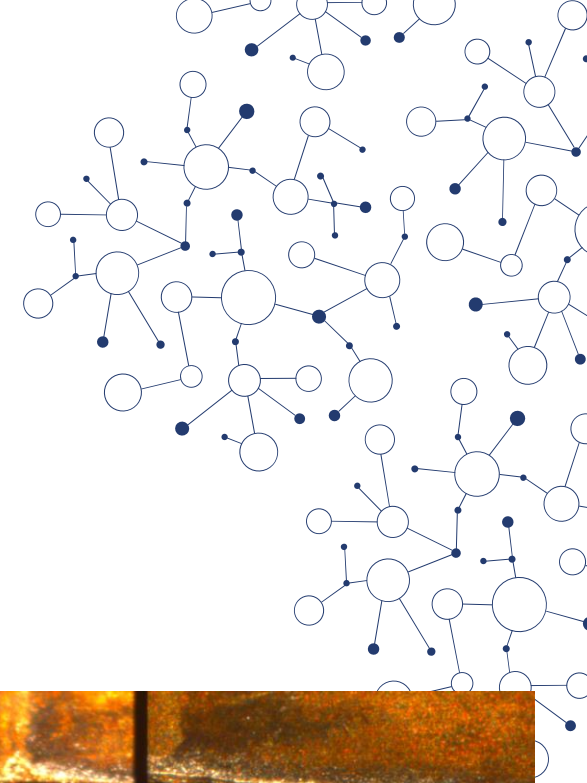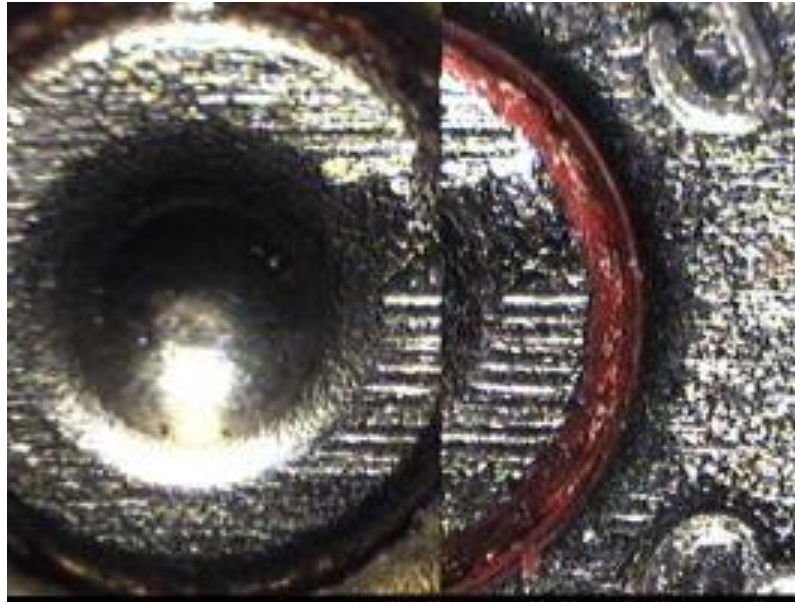
CSAFE 1.0 Accomplishments

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
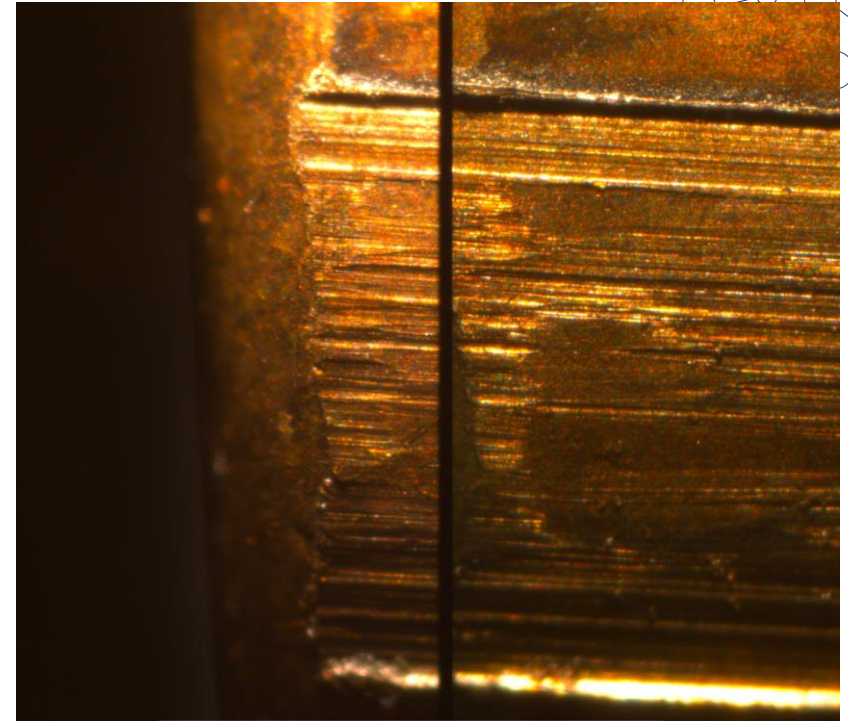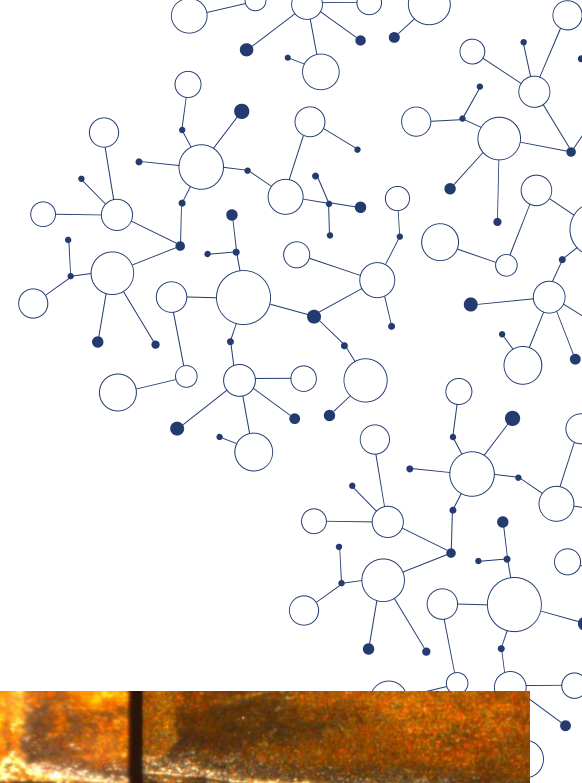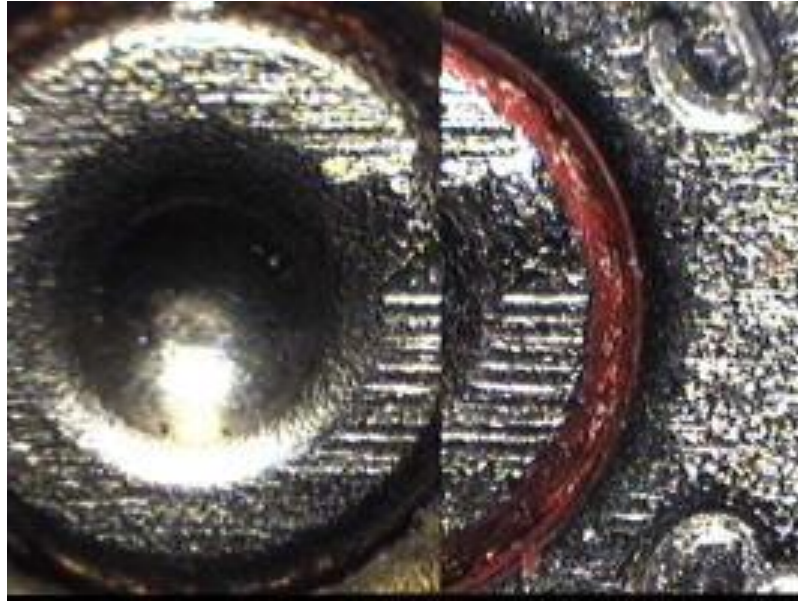
CSAFE 2.0 Projects and Lead Investigators

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 if 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
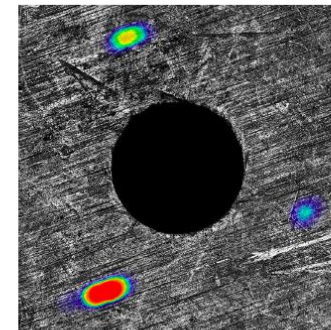- Performance of NIST CMC algorithm with subclass present

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
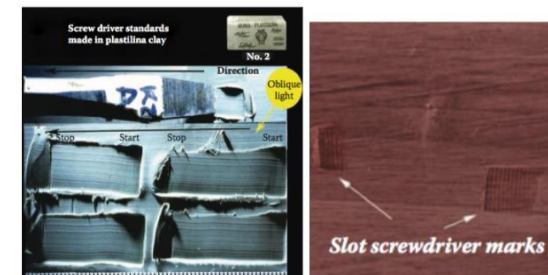
Iteration #1…

Toolmarks:
- Screwdriver brand
- Screwdriver # (of same brand)
- Angle, surface material (soft to hard), striation vs. imprint, etc.
- Iterations per angle/surface/etc. combination
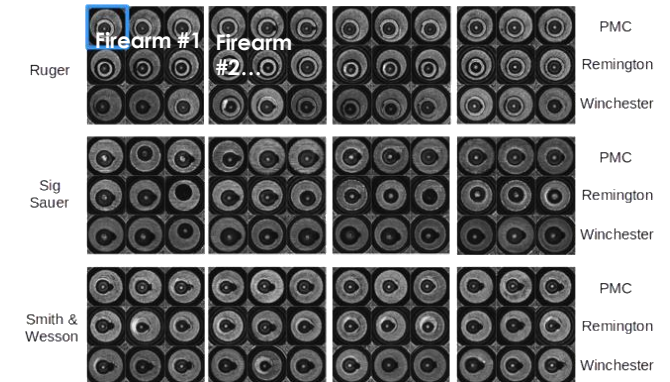
Many degrees of freedom in screwdriver mark
Baiker et al. (2016).
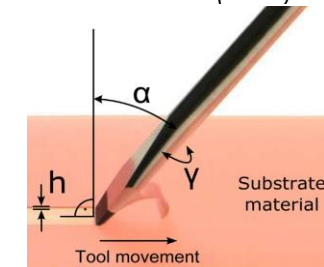
Screwdriver striation (L) and impression marks (R).
Petraco (2011).

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