Firearms and Toolmark Analysis

Presented by: Dr. Heike Hofmann
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
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
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.
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