Firearms and Tool Marks

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Firearm and Tool Mark Identification

- Were the evidence tool marks produced by the same tool?
- Was an evidence mark produced by the evidence tool?

Firearm “tools”
- Revolver
- Pistol
- Rifle
- Shotgun

Source: SWGGUN

Non-firearm tools
- Screwdriver
- Pry bar
- Wire cutter
- Pliers
- Lock pick

Source: SWGGUN

Common tool mark evidence
- Bullet
- Cartridge case

Source: SWGGUN

Common tool mark evidence
- Lock
- Safe
- Window still
- Wire

Source: aegisacademy.com
Bullets and Cartridge Cases – Regions of Interest

Bullets have striated tool marks from the barrel rifling.

Cartridge cases have impressed and striated tool marks from various sources.

Casings constitute over 90% of the NIBIN national database entries for firearm identification.
Firearm Identification – Current Practice

Compare class characteristics - Measurable features that indicate a restricted group source

Compare individualizing tool marks (subjective):
• Does the agreement exceed the best agreement demonstrated between tool marks from different tools?
• Is the agreement consistent with the agreement demonstrated by tool marks from the same tool?

Render an opinion:
• Identification
• Exclusion
• Inconclusive
• Unsuitable

Current Practice is Under Scrutiny

• 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.”

• PCAST 2016: “PCAST finds that firearms analysis currently falls short of the criteria for foundational validity, because there is only a single appropriately designed study to measure validity and estimate reliability.”

• PCAST 2016: “A second – and more important – direction is ... to convert firearms analysis from a subjective method to an objective method...”

• President’s Council of Advisors on Science and Technology, “Forensic science in criminal courts: Ensuring scientific validity of feature-comparison methods”, Washington DC, 2016.
NIST Firearms and Tool Marks Focus Area

Goals:
• Metrology infrastructure for objective firearm and tool mark examination
• Scientifically-justified protocols to quantify the weight of the evidence.

Focus:
• Measurement methods, quality assurance, and standards.
• Objective comparison metrics and algorithms
• Knowledge base for similarity and variability of tool marks
• Quantitative expressions for the weight of evidence.
From 2D to 3D

2D reflectance microscopy images

Comparison microscopy

3D topography images

Virtual comparison microscopy

- Higher reproducibility and focus on actual topography
- Measure once, compare often
- Well suited for numerical analysis
- Already common for database search
- Virtual comparison microscopy is ready for case work
Physical Standards for Measurement Traceability and Quality control

- Provide SRM bullets and cartridge cases.
- Provide reference images for comparison.
- Laboratories regularly check their measurements with the reference.

Standards for Individual Error Sources and Measurement Uncertainty Evaluation

Results are applicable to a wider range of measurands and enable check of instrument specifications.
Objective Similarity Metrics

Number/Quality of Matching Features

Area or Profile Similarity (e.g., correlation coefficient)

Congruent Matching Striae (CMS)
Congruent Matching Cells

Breech face impressions from the same firearm

24 CMCs

Breech face impressions from different firearms

0 CMCs

Open-access research database of firearm tool marks on bullets and cartridge cases:

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

www.nist.gov/forensics/ballisticsdb
Characterizing the Weight of Evidence

- Characterize score distributions for known matching and known non-matching comparisons

- Characterize the weight of evidence for a particular score
  - Error rates
  - Likelihood ratio
  - ....

Initial Results “Population Study” (CMC Breech Face)

- No sample triage.
- Consistent distribution of CMC scores for different-source comparisons.
- Results Indicate potential for low false positive error rates.
Major Activities

1. Quality assurance, reference artifacts, and documentary standards

2. Metrics and algorithms for objective identification

3. Tool mark database for research and validation

4. Quantitative evaluation weight of evidence

5. Specifications for NIBIN interoperability

6. Tool mark identification for non-firearm tools
Thank You

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