SENSOFAR® METROLOGY

S neox

3D Firearm Identification

SensoMATCH®
bullet comparison software

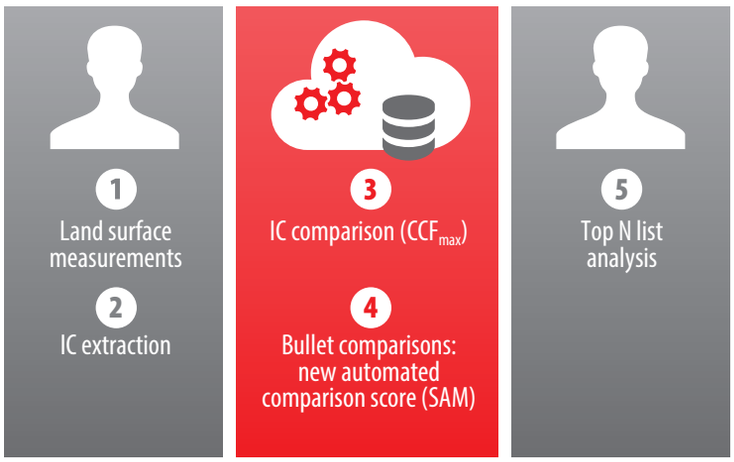
Land surface measurement

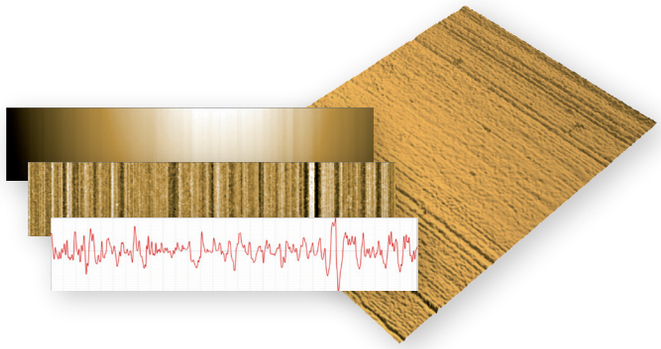
Introduction

To match a bullet to a firearm, a trained examiner traditionally uses a microscope to compare the striations on each available 'land area' on the bullet to the land areas on a (known) bullet fired from the firearm. Although it has been reliable, this process is tedious and subjective.

Methodology

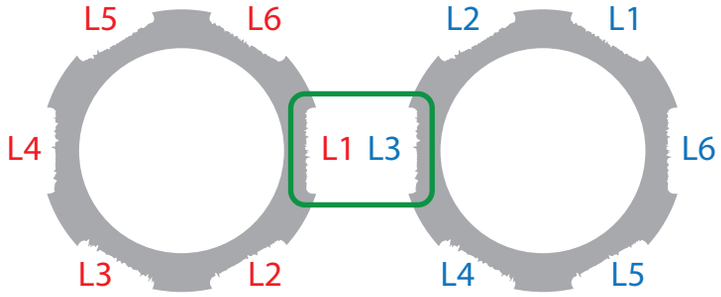
Sensofar is working to provide quantitative data on bullet lands using optical 3-dimensional metrology. **SensoMATCH®** is a new program that fully automates IC and bullet comparison. The process typically consists of five steps:





IC surface & mean profile

Pairs of IC surfaces are mathematically compared by extracting mean profiles from each surface and calculating a cross correlation function (CCF_{max}). Identical profiles have a CCF_{max}=1.0. Lower correlations yield a lower CCF_{max} value, typically 0.2 - 0.4. Higher scores thus indicate the confidence level of a match.



IC	L1	L2	L3	L4	L5	L6	Seq. Av
L1	0.28	0.31	**0.88**	0.27	0.28	0.36	0.30
L2	0.37	0.28	0.27	**0.88**	0.35	0.22	0.28
L3	0.24	0.28	0.24	0.33	**0.89**	0.27	**0.77** SAM
L4	0.33	0.23	0.35	0.41	0.24	0.27	0.29
L5	**0.87**	0.24	0.27	0.31	0.26	0.29	0.25
L6	0.22	**0.83**	0.29	0.25	0.30	0.34	0.33

A single comparison of 2 bullets each with 6 lands results in 36 CCF_{max} scores in a 6x6 matrix

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This comparison task scales very rapidly – comparing 15 unknown bullets to 20 known bullets results in 10,800 scores in 300 matrices.

SensoMATCH® streamlines bullet comparison

To simplify analysis, we can calculate a single composite score for each bullet pair – **Sequence Average Maximum (SAM)** – that provides a clear indication of a match between bullets. The user specifies the threshold value that is used to identify matches (see graphic below right).

The entire John Hamby dataset of 15 vs 20 bullets (10,800 comparisons) can be processed in approximately 4 seconds, resulting in a spreadsheet that identifies the top matches for each unknown bullet.

Additional features

SensoMATCH® has additional features that make it an ideal tool for research in bullet comparisons based on 3D surface metrology:

- Training mode.
- **SensoMAP** template for IC comparison using customized data processing and comparison parameters.
- Missing lands compatibility.
- Comparing a set of known bullets to itself is useful for calculating statistical values for 'Known Matches vs. Known Non-Matches' and then using this to define **SAM** thresholds (see graphic right).
- This approach to data analysis can be made using a variety of optical metrology systems, including the Sensofar family of optical metrology systems.

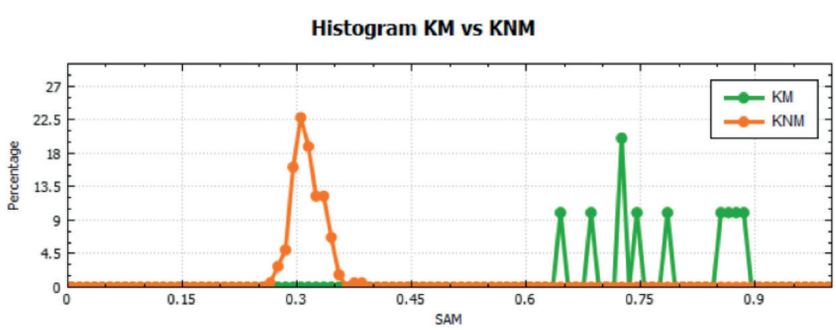
SensoMATCH results

SAM	B	C	D	E	F	H	J	L	M	Q	S	U	X	Y	Z
1 b1	0.33	0.77	0.32	0.32	0.77	0.32	0.31	0.28	0.30	0.30	0.31	0.31	0.30	0.32	0.34
1 b2	0.28	0.73	0.31	0.31	0.70	0.32	0.31	0.29	0.32	0.33	0.31	0.31	0.32	0.32	0.32
2 b1	0.29	0.33	0.30	0.31	0.31	0.81	0.29	0.30	0.30	0.31	0.29	0.32	0.28	0.32	0.29
2 b2	0.29	0.33	0.31	0.31	0.31	0.81	0.30	0.29	0.29	0.32	0.30	0.31	0.31	0.31	0.30
3 b1	0.28	0.30	0.32	0.30	0.32	0.28	0.33	0.28	0.29	0.30	0.61	0.29	0.64	0.30	0.31
3 b2	0.29	0.29	0.31	0.31	0.30	0.29	0.31	0.30	0.29	0.29	0.61	0.30	0.78	0.32	0.30
4 b1	0.67	0.31	0.33	0.33	0.31	0.31	0.32	0.29	0.30	0.32	0.32	0.33	0.30	0.35	0.33
4 b2	0.61	0.32	0.33	0.35	0.31	0.29	0.31	0.32	0.32	0.32	0.32	0.35	0.31	0.34	0.34
5 b1	0.30	0.34	0.88	0.37	0.34	0.29	0.33	0.30	0.35	0.33	0.32	0.31	0.29	0.34	0.85
5 b2	0.30	0.36	0.88	0.39	0.35	0.31	0.33	0.32	0.36	0.35	0.34	0.32	0.32	0.35	0.84
6 b1	0.27	0.31	0.32	0.78	0.32	0.30	0.27	0.28	0.62	0.28	0.28	0.28	0.28	0.74	0.32
6 b2	0.29	0.31	0.34	0.74	0.32	0.28	0.30	0.28	0.72	0.32	0.31	0.29	0.31	0.68	0.31
7 b1	0.33	0.32	0.33	0.32	0.30	0.32	0.85	0.30	0.29	0.31	0.36	0.30	0.31	0.32	0.33
7 b2	0.32	0.33	0.31	0.33	0.31	0.29	0.82	0.29	0.29	0.30	0.34	0.30	0.30	0.33	0.33
8 b1	0.31	0.32	0.31	0.31	0.29	0.33	0.29	0.78	0.30	0.29	0.32	0.32	0.30	0.32	0.28
8 b2	0.31	0.29	0.33	0.32	0.28	0.31	0.28	0.79	0.31	0.30	0.32	0.32	0.28	0.31	0.28
9 b1	0.30	0.33	0.32	0.31	0.35	0.33	0.30	0.36	0.31	0.30	0.33	0.69	0.32	0.32	0.33
9 b2	0.29	0.32	0.32	0.31	0.31	0.31	0.32	0.33	0.32	0.29	0.32	0.71	0.32	0.32	0.31
10 b1	0.30	0.28	0.32	0.34	0.28	0.30	0.28	0.26	0.31	0.55	0.32	0.31	0.29	0.34	0.34
10 b2	0.31	0.32	0.34	0.36	0.32	0.31	0.31	0.31	0.30	0.60	0.34	0.32	0.32	0.35	0.32

NIST results

B	C	D	E	F	H	J	L	M	Q	S	U	X	Y	Z
4	1	5	6	1	2	7	8	6	10	3	9	3	6	5

John Hamby test is correctly solved (SAM threshold 0.5)



Establishing SAM threshold based on the histogram of CFF_{max} values

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