FORensic Marks Search - KIRAS Project

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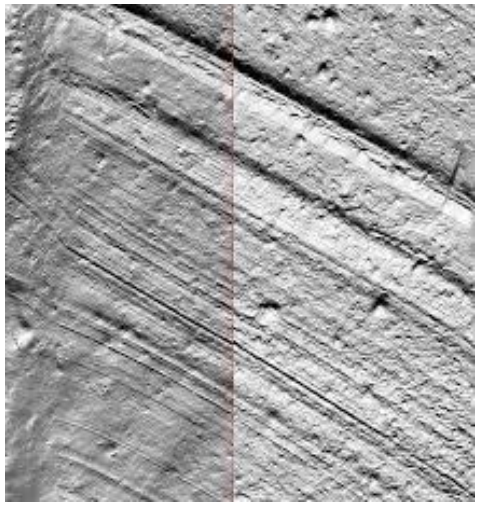
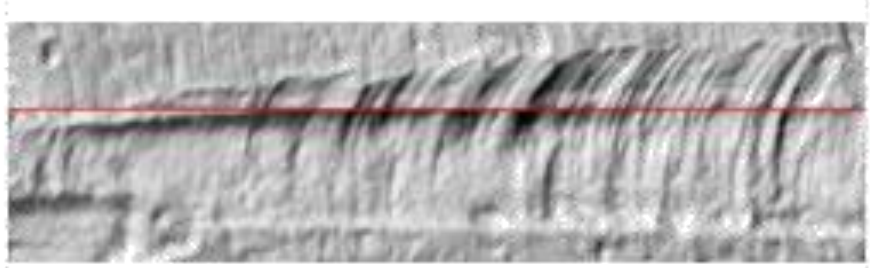
Bundesministerium für Verkehr, Innovation und Technologie
FFG
KIRAS Sicherheitsforschung

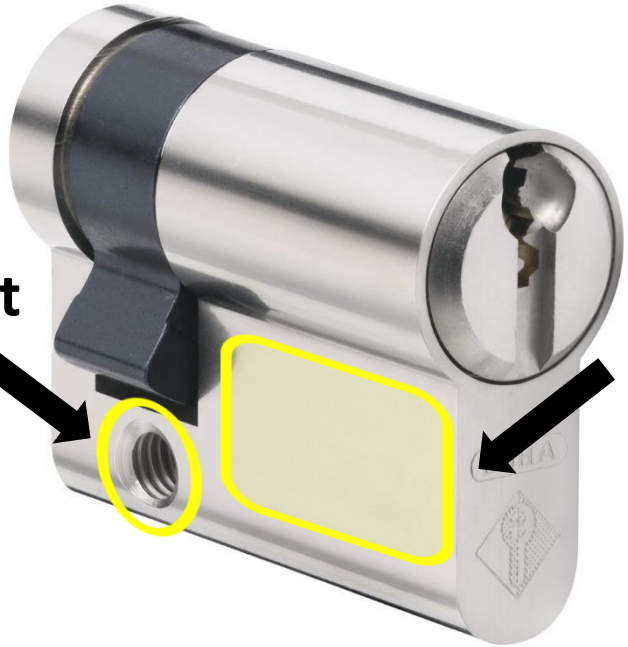
FORMS?

- FORMS objectives
  - (semi-)automatic search and retrieval of similar tool marks in criminal offenses
  - Allows for searching marks in a database to detect crime series or link crimes
- Partners
  - CogVis Software und Consulting GmbH
  - Vienna Centre for Societal Security – VICESSE
  - Bundeskriminalamt – Büro für Kriminaltechnik
- Details
  - 1.9.2015-31.08.2017
  - Funded by: FFG – KIRAS





FORMS?

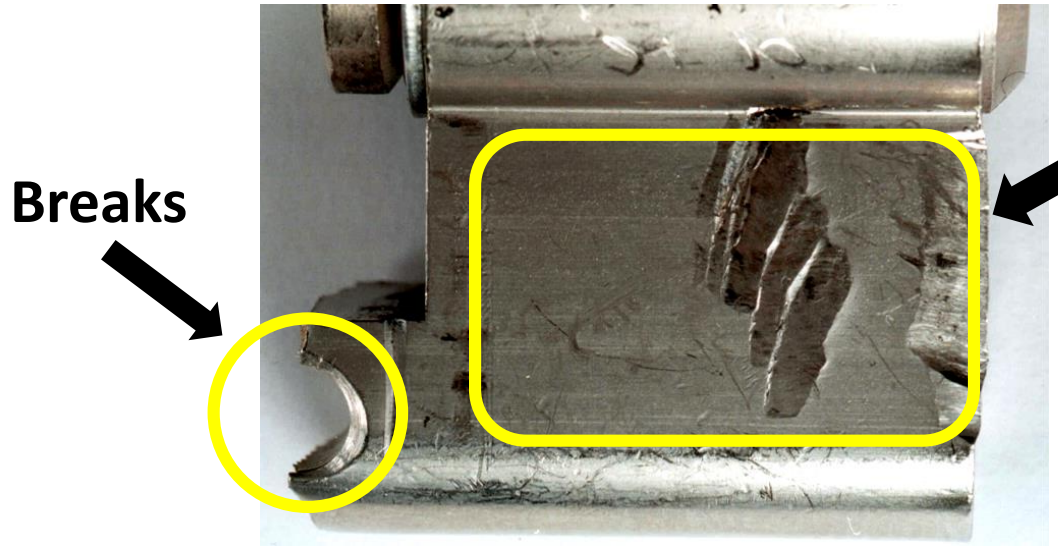


Lock cylinder

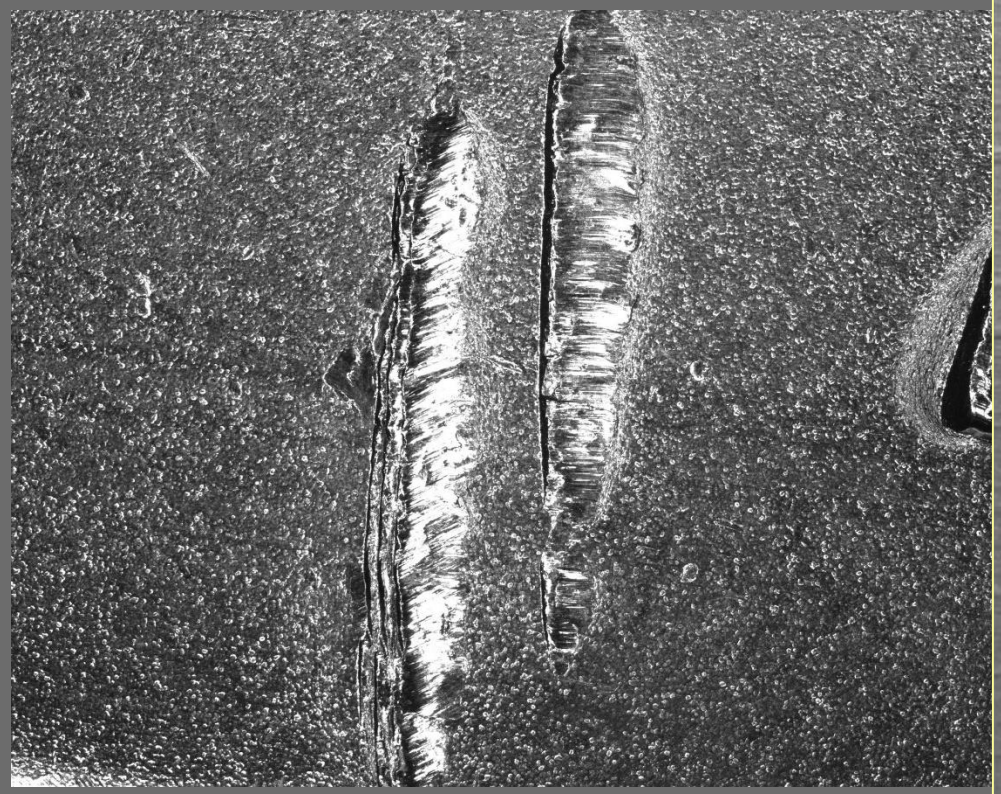
Tool

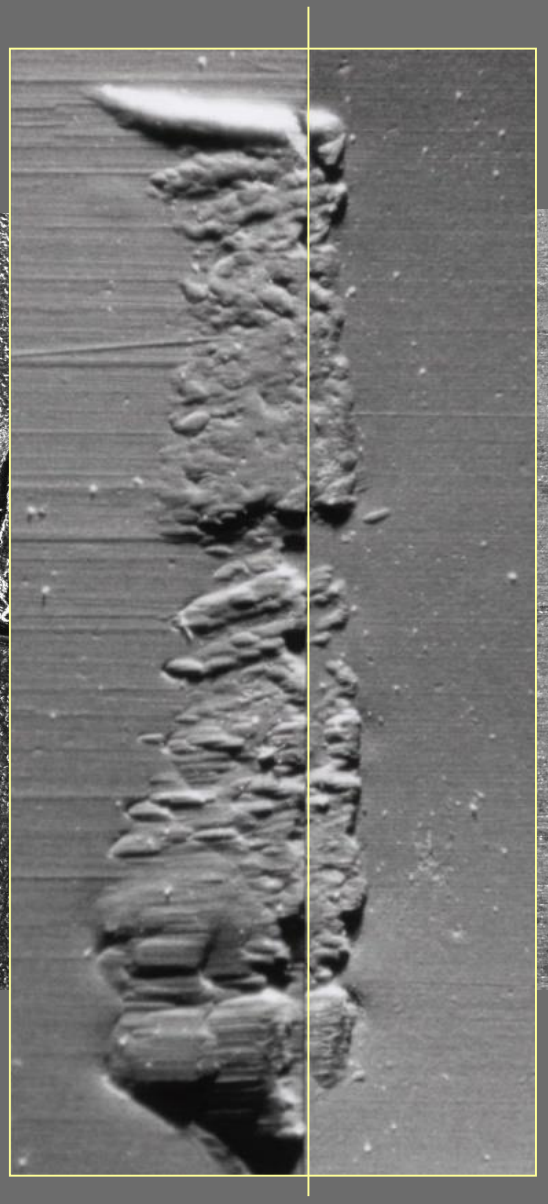
FORMS?

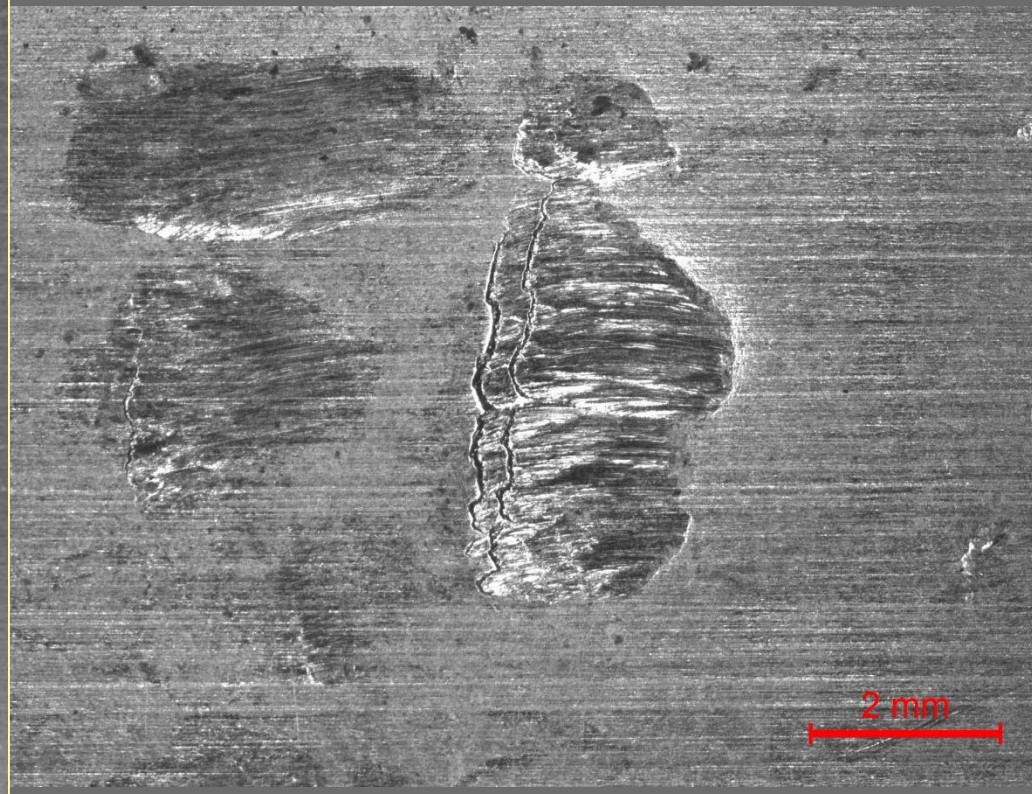
Before



After







Examples

FORMS 〉 Database

- Stats
  - ~ 300 Toolmarks (and growing)

Marks/Tool	Tools	Images	Images/ Total Images [%]
1	63	63	21
2	63	126	43
3	18	54	18
4	6	24	9
5	2	10	3
6	2	12	4
7	1	7	2
Total	155	296	100

Procedure

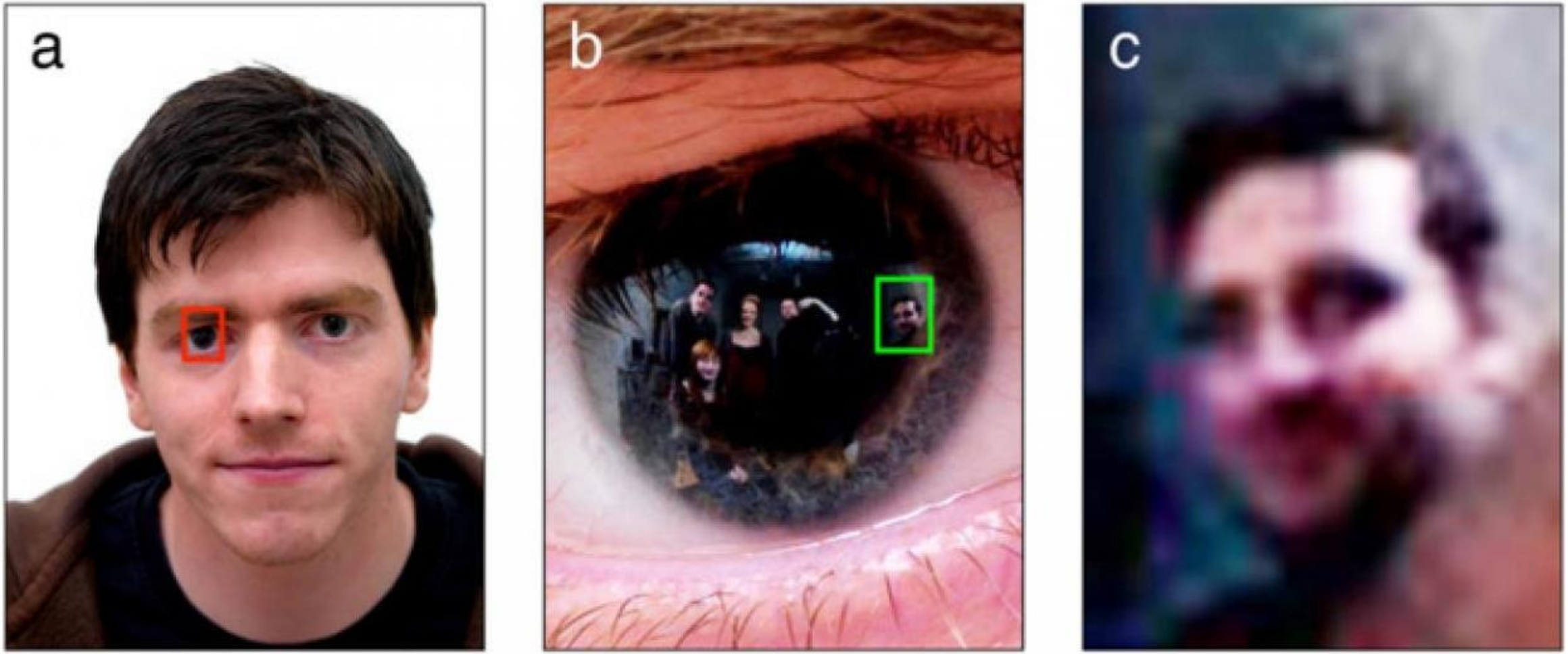
Procedure 〉Standardized Image

Procedure 〉Standardized Image

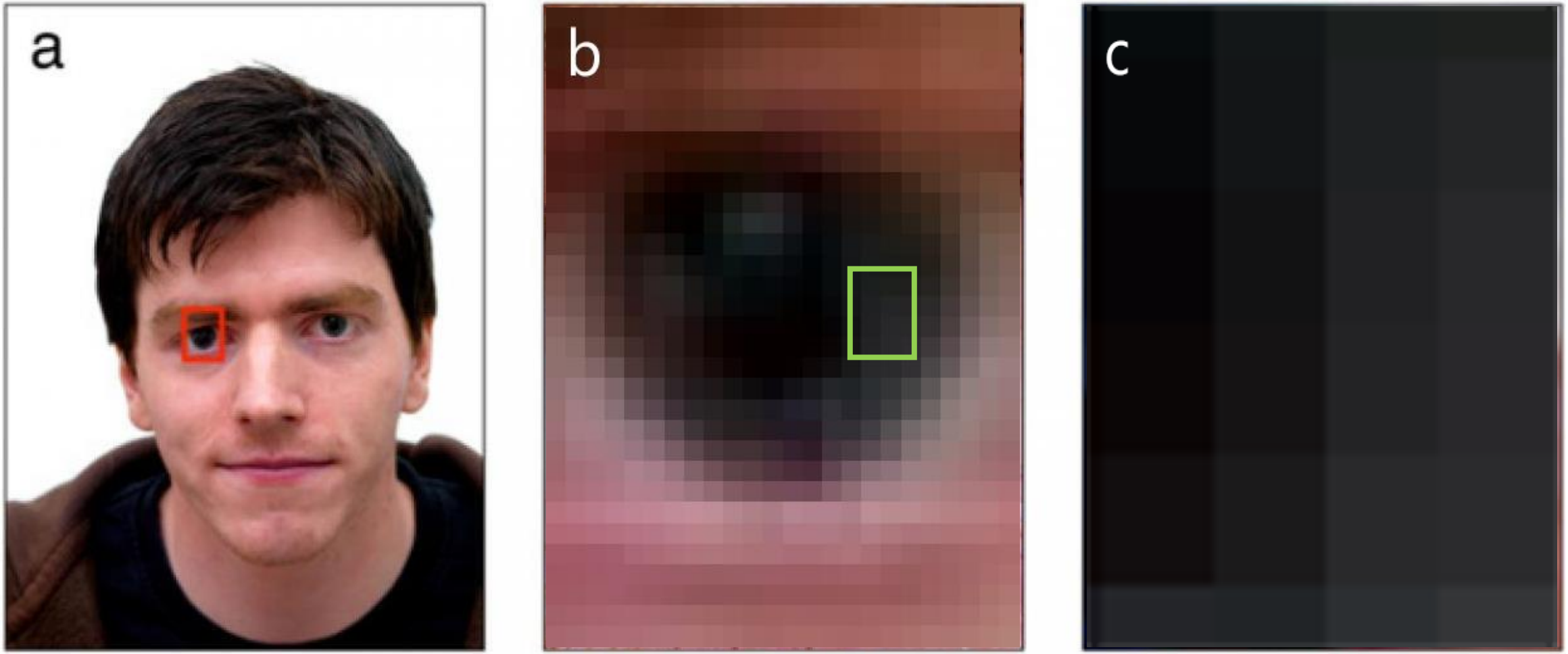
Procedure 〉Standardized Image

Procedure 〉Standardized Image

Procedure ⟩ TV „Enhance“

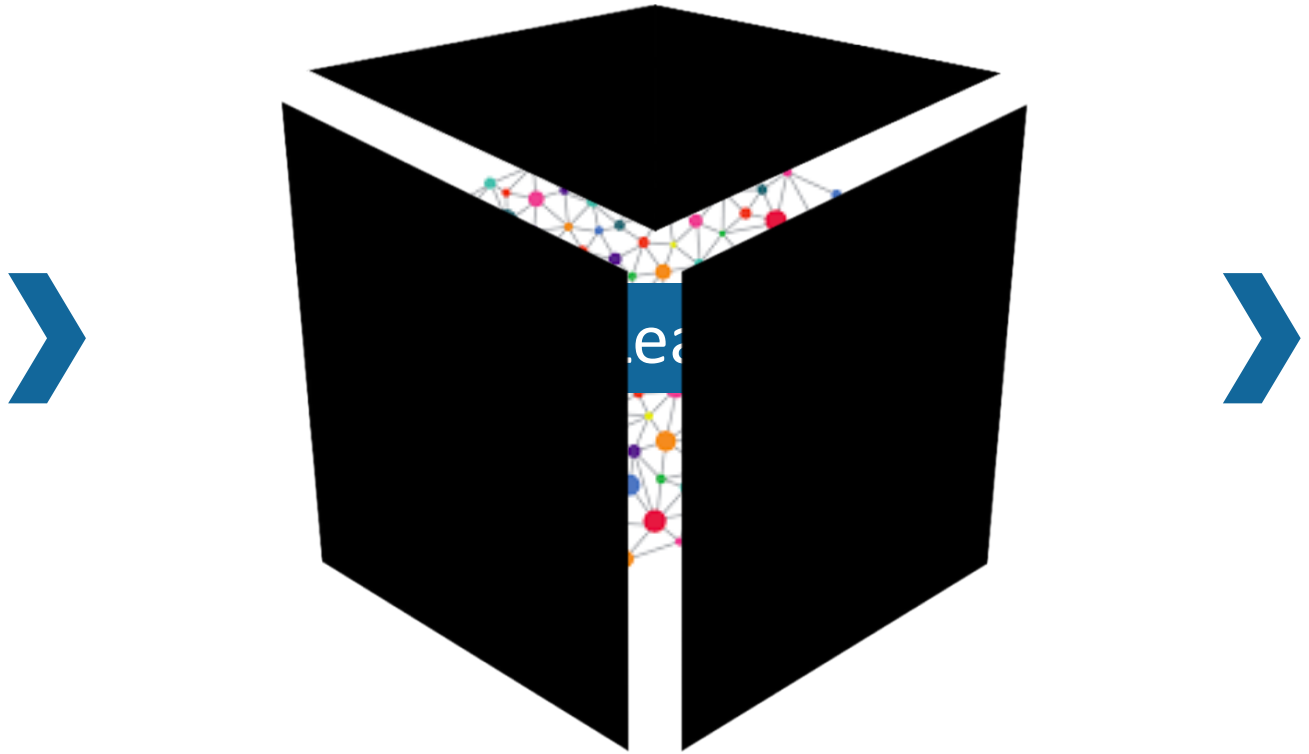


Procedure 〉Real Enhance

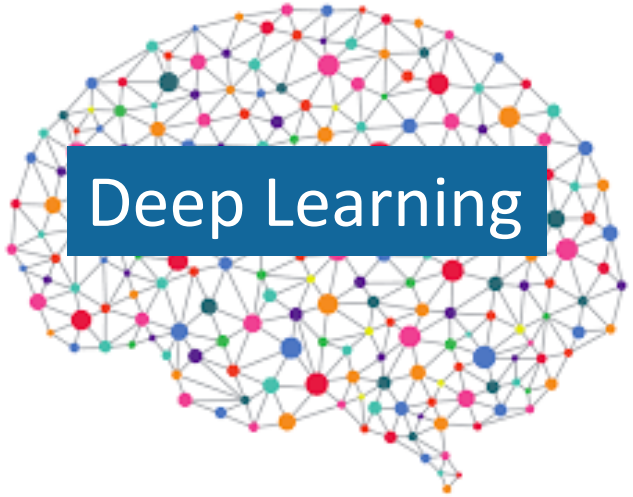


Procedure 〉Annotate + Upload

Procedure 〉Processing on Server

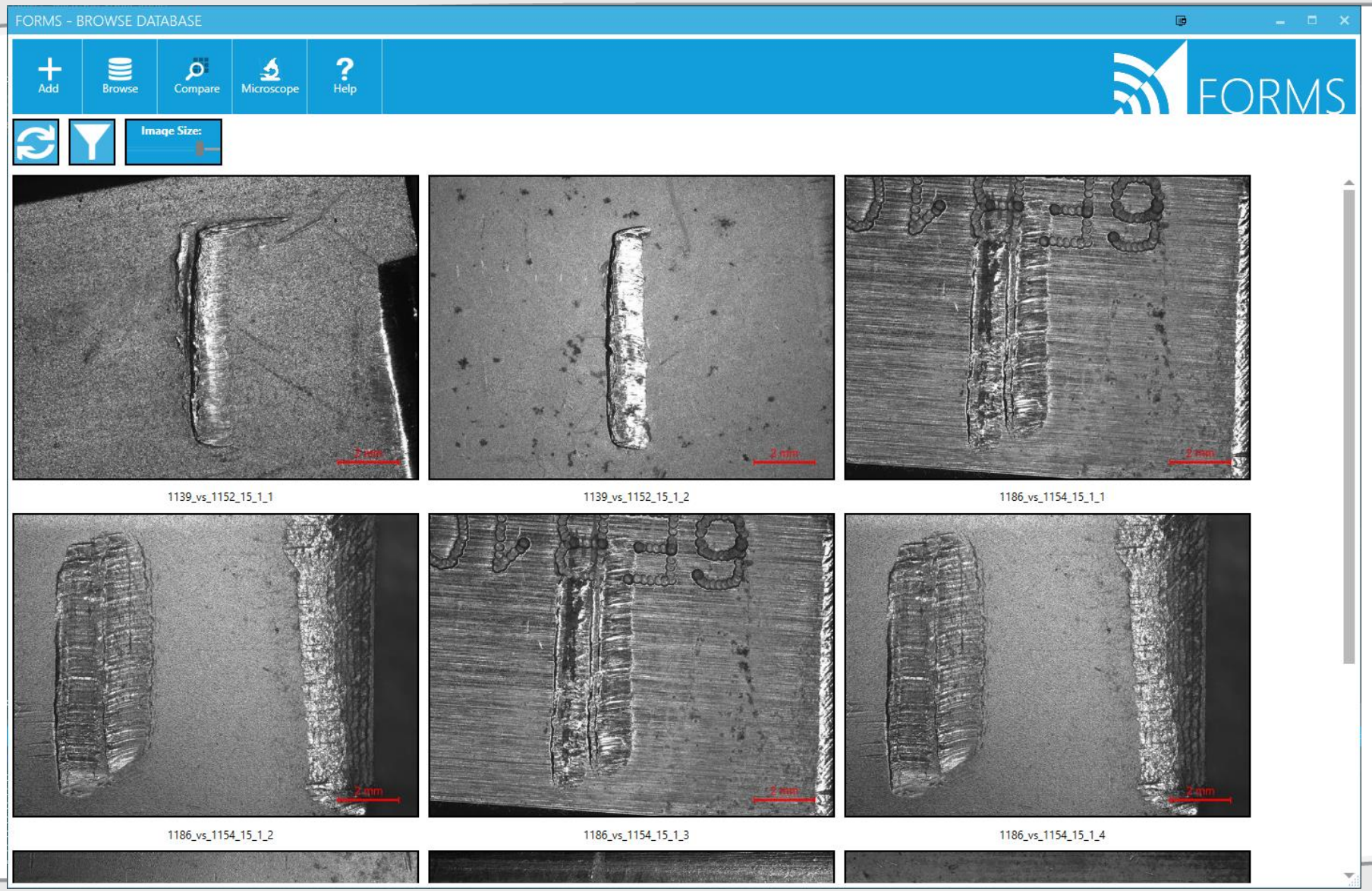


Procedure 〉Processing on Server

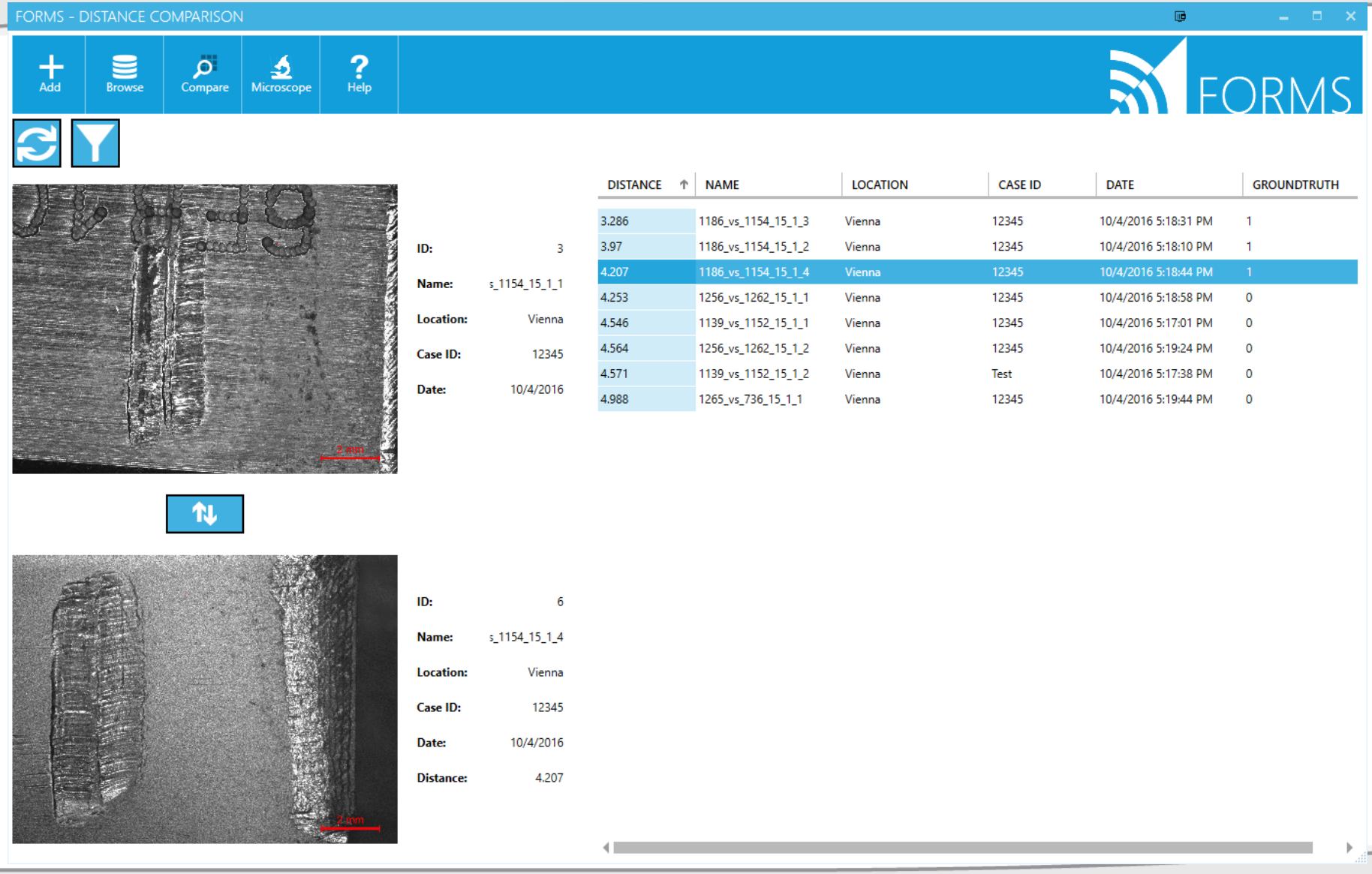


more on this later…

Procedure 〉Browse Database

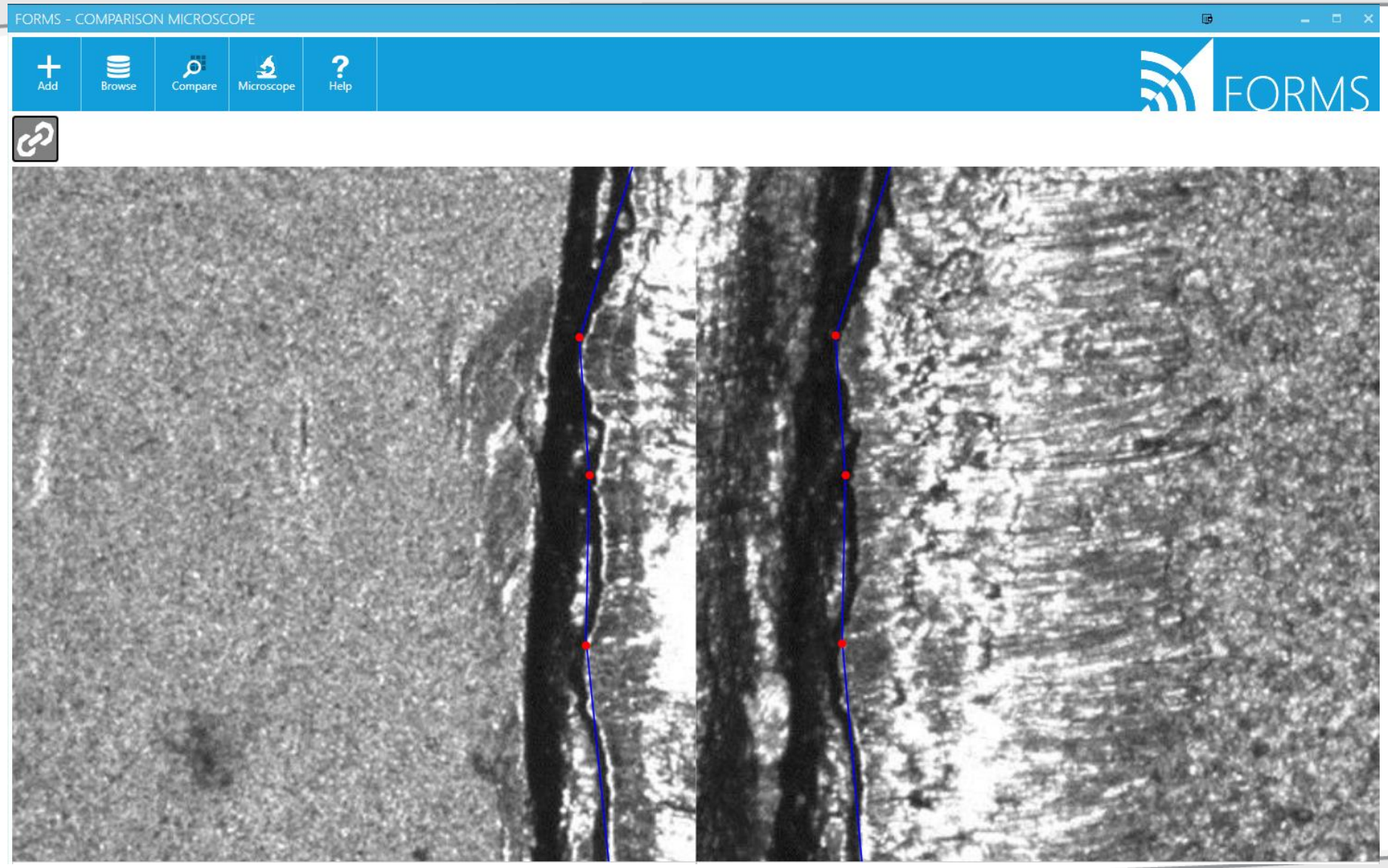


Procedure 〉Find Similarities



DISTANCE	NAME	LOCATION	CASE ID	DATE	GROUNDTRUTH
3.286	1186_vs_1154_15_1_3	Vienna	12345	10/4/2016 5:18:31 PM	1
3.97	1186_vs_1154_15_1_2	Vienna	12345	10/4/2016 5:18:10 PM	1
4.207	1186_vs_1154_15_1_4	Vienna	12345	10/4/2016 5:18:44 PM	1
4.253	1256_vs_1262_15_1_1	Vienna	12345	10/4/2016 5:18:58 PM	0
4.546	1139_vs_1152_15_1_1	Vienna	12345	10/4/2016 5:17:01 PM	0
4.564	1256_vs_1262_15_1_2	Vienna	12345	10/4/2016 5:19:24 PM	0
4.571	1139_vs_1152_15_1_2	Vienna	Test	10/4/2016 5:17:38 PM	0
4.988	1265_vs_736_15_1_1	Vienna	12345	10/4/2016 5:19:44 PM	0

Procedure 〉Compare Toolmarks



Methodology

Methodologie 〉Deep Learning

- Advantages
  - “Learned“ Features
  - Flexible
  - Fast (GPU mandatory)
  - Robust
- Disadvantages
  - Data needed for training
  - “Blackbox”

Deep Learning 〉Google Image Search

Query

Deep Learning ⟩ Google Image Search

Query

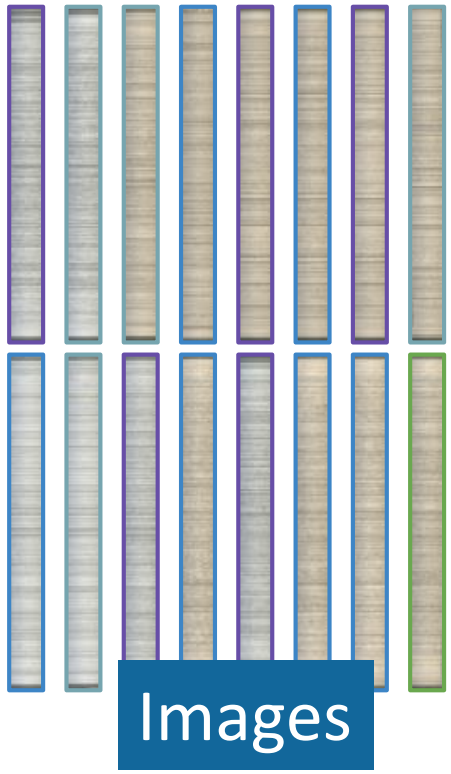
Deep Learning ⟩ Google Image Search

Query

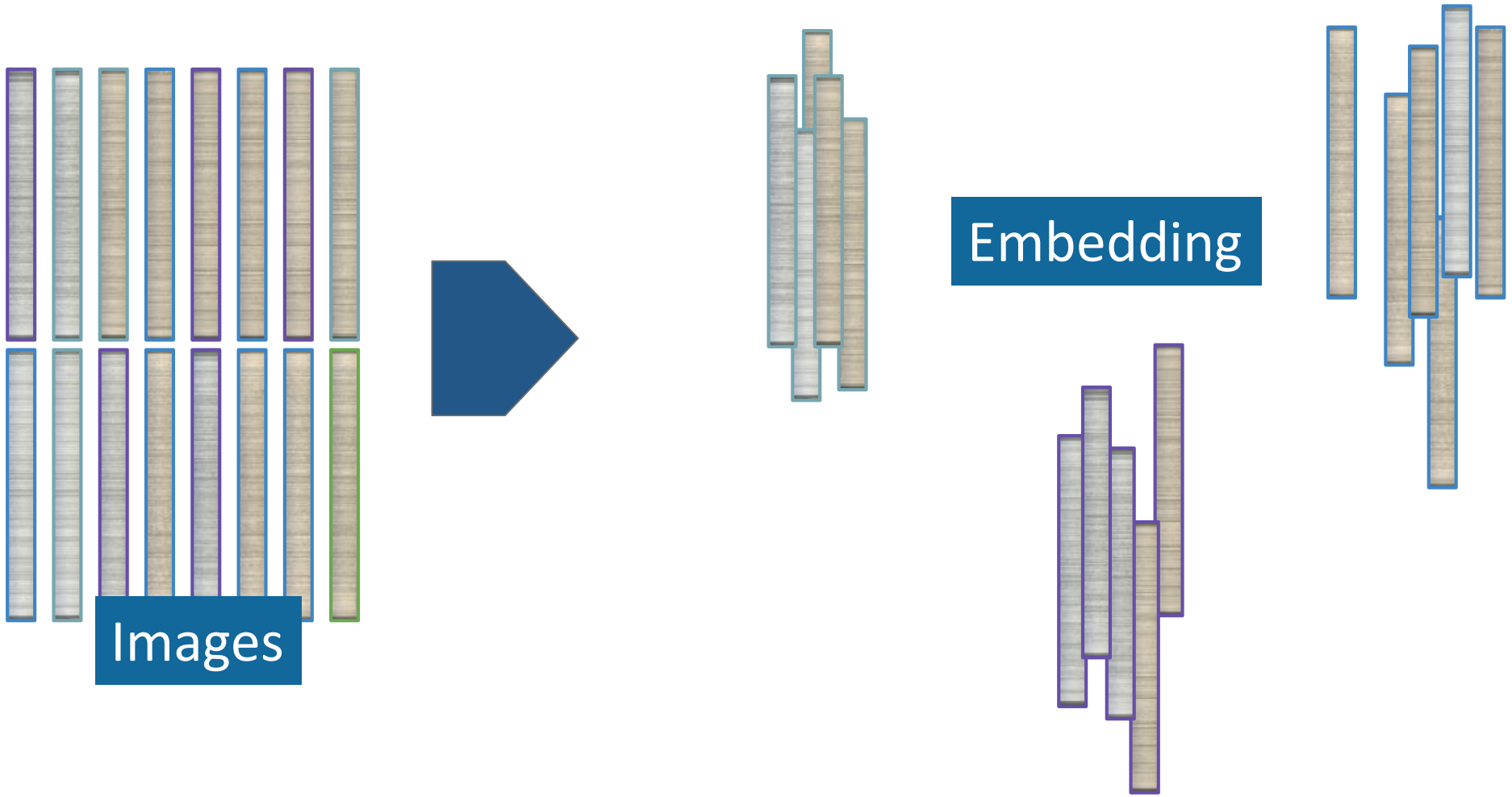
"Statue of Liberty"

Deep Learning 〉Embedding

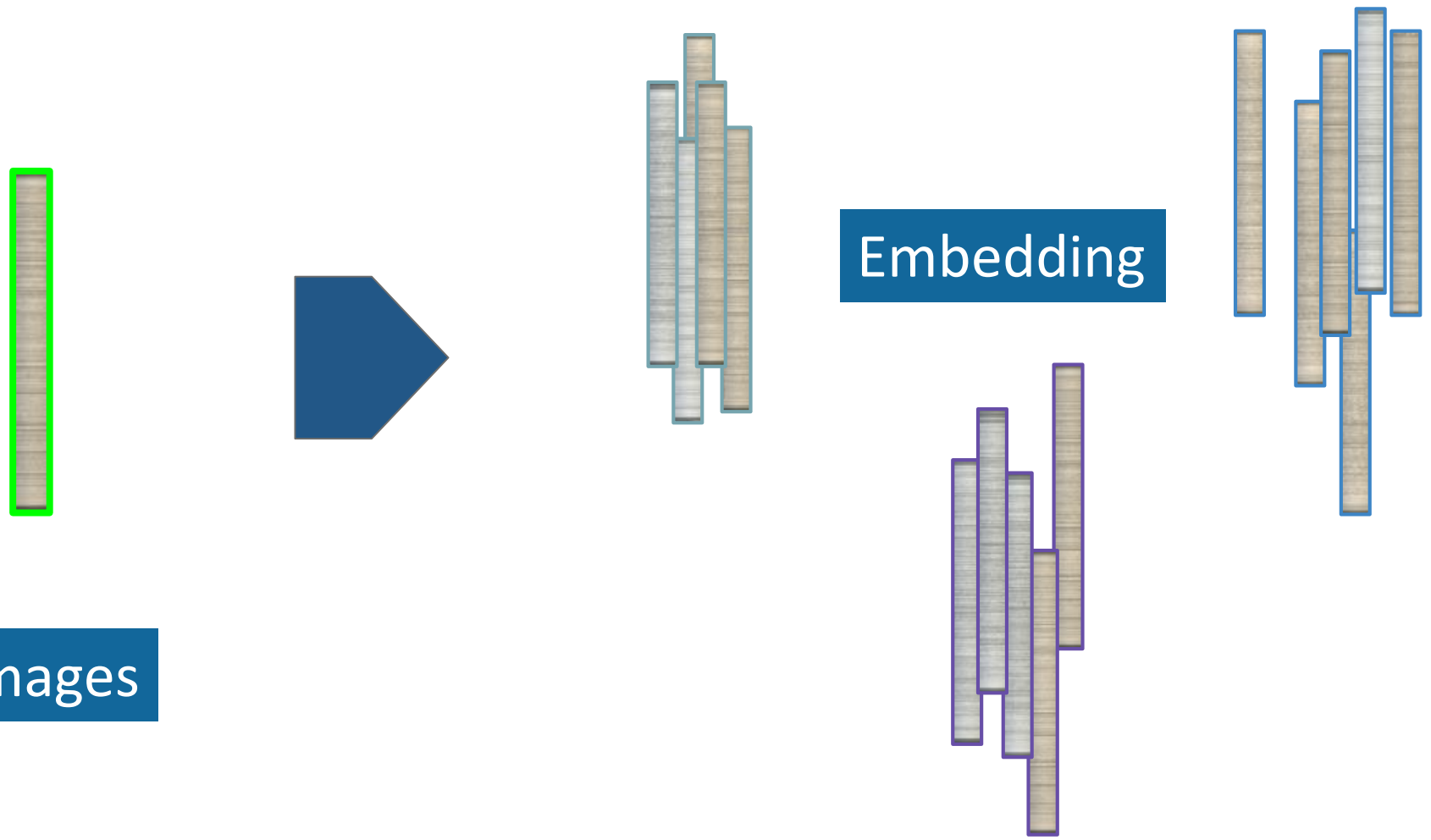
Deep Learning 〉Embedding



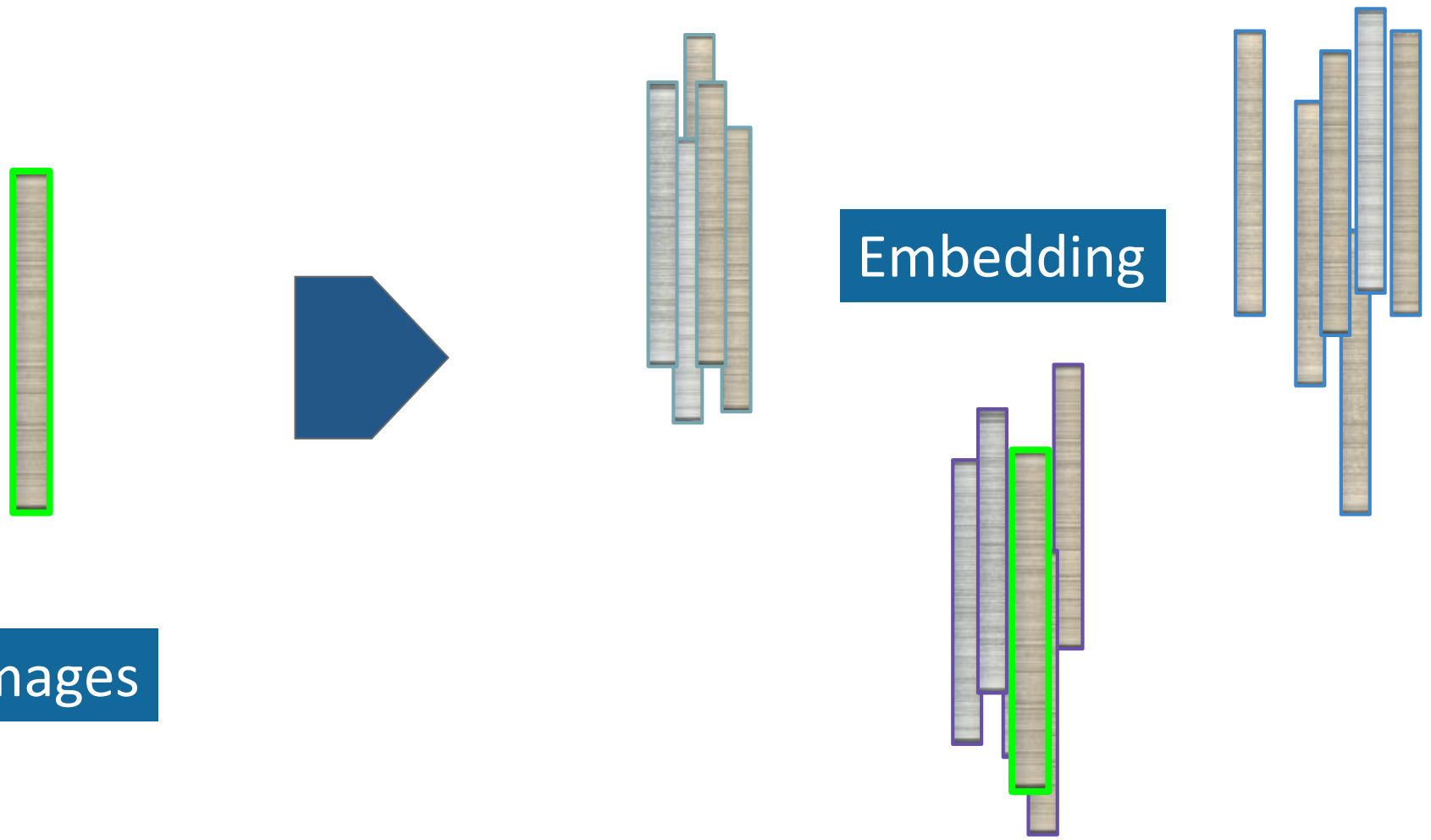
Deep Learning 〉Embedding



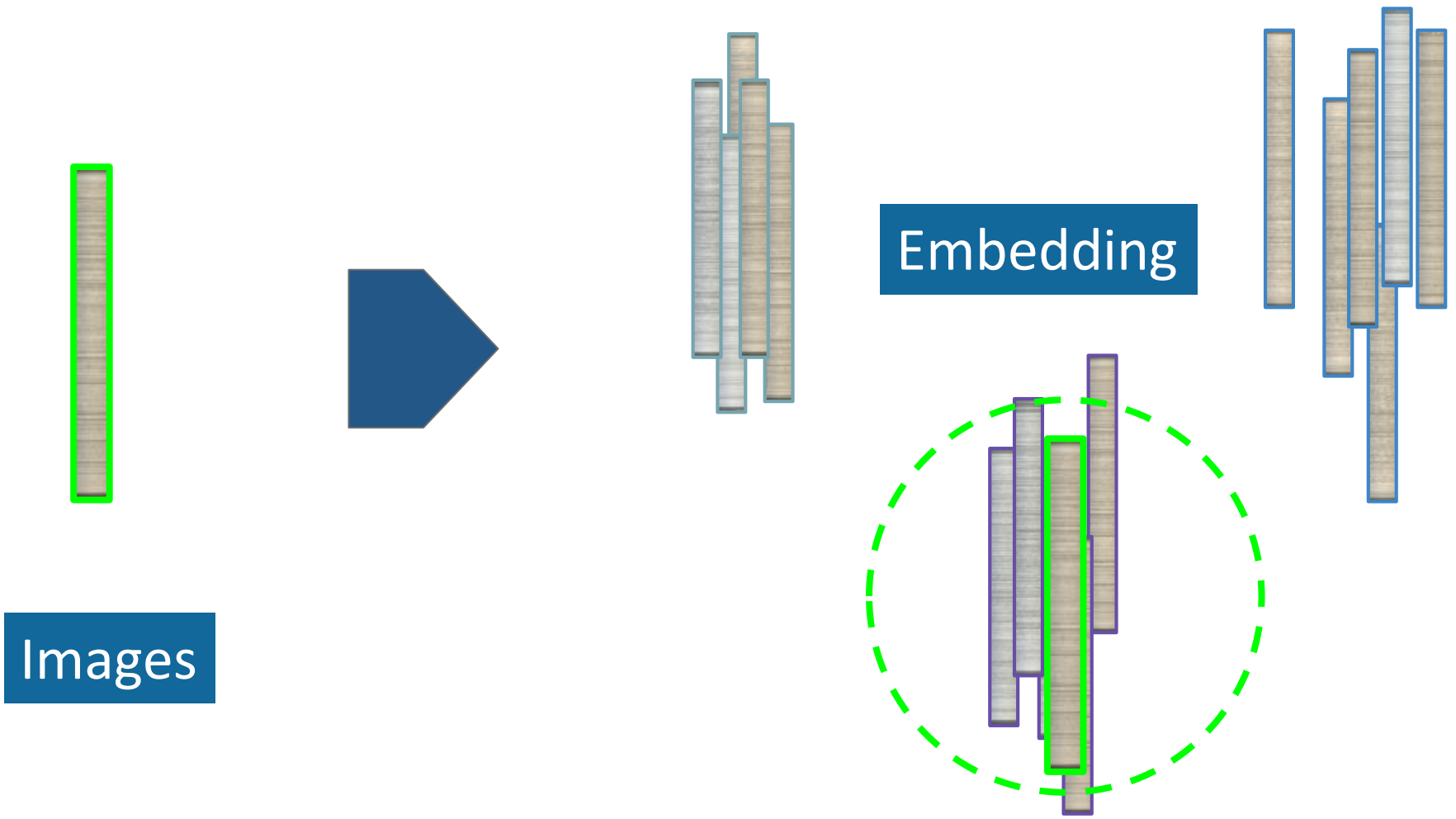
Deep Learning 〉Embedding



Deep Learning 〉Embedding



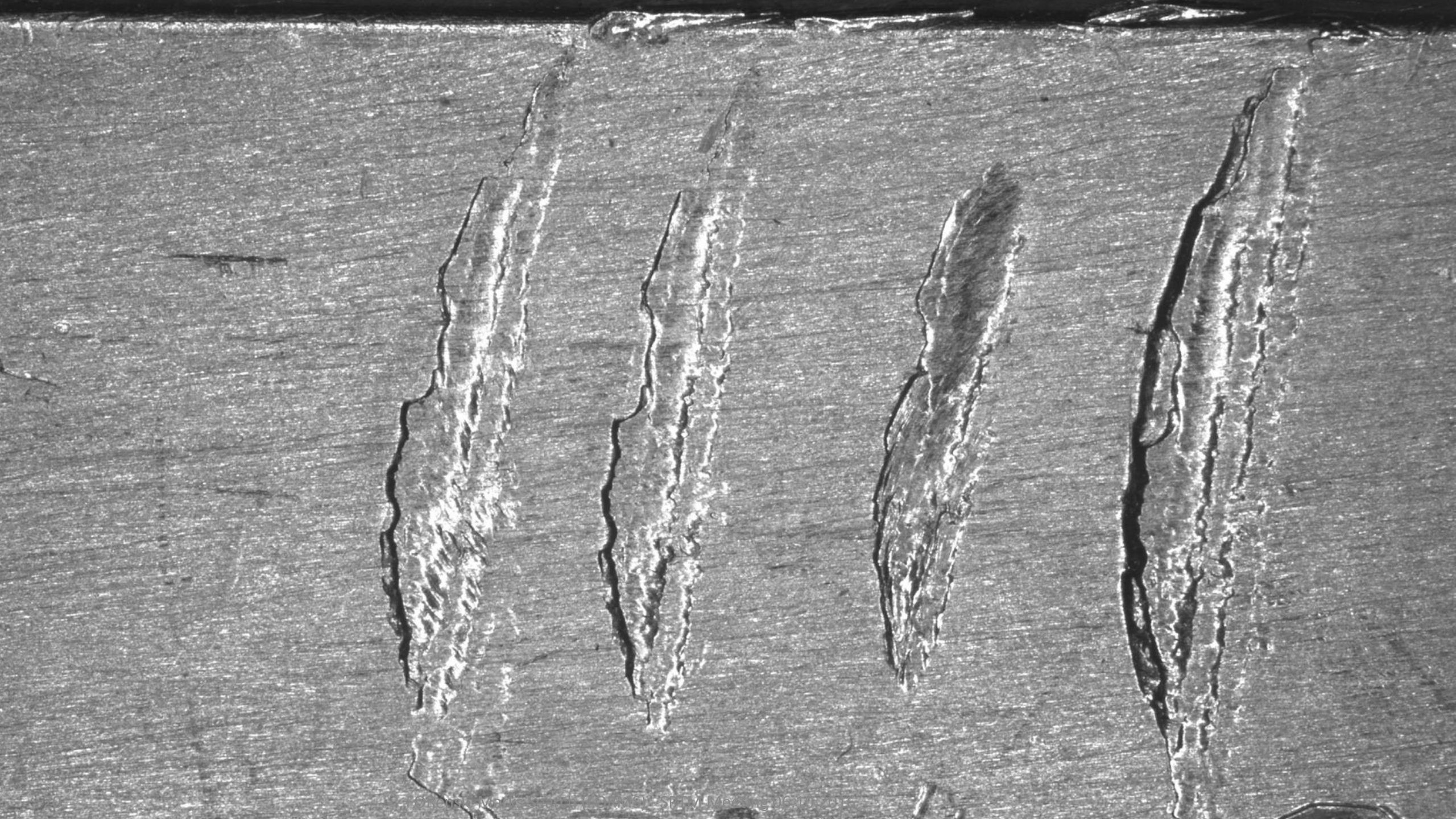
Deep Learning 〉Embedding

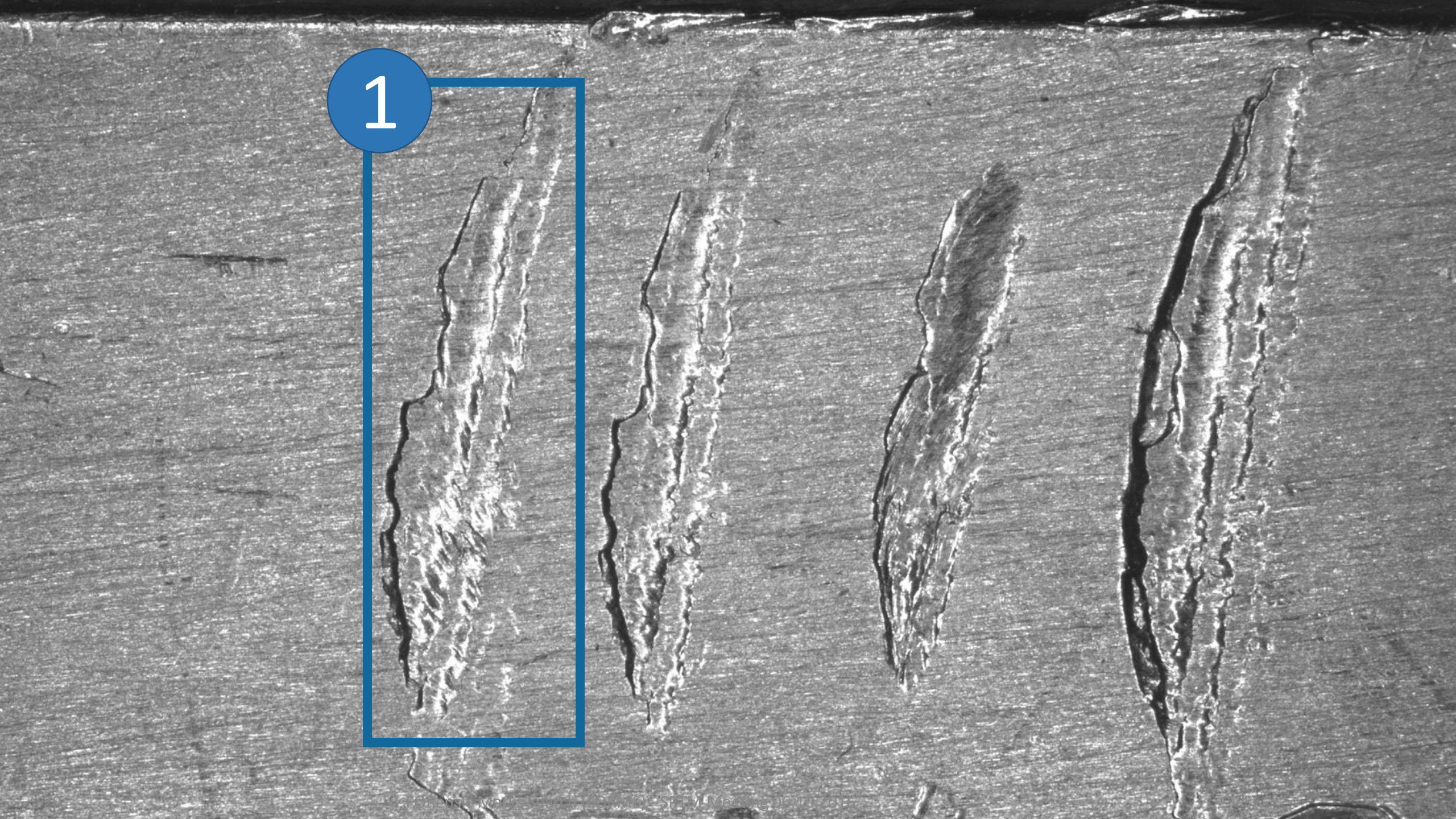


Methodology 〉Ground Truth

- Regions of Interest (ROI)
  - Multiple marks / image
  - Extraction of ROI
  - Advantage: fast & easy
  - Disadvantage: only 300 images

- Polylines / patches
  - „Inverse“ comparison Microscope
  - Annotate matching Patches
  - Verification using magnification
  - Advantages: many patches / image
  - Disadvantages: time consuming, tool necessary

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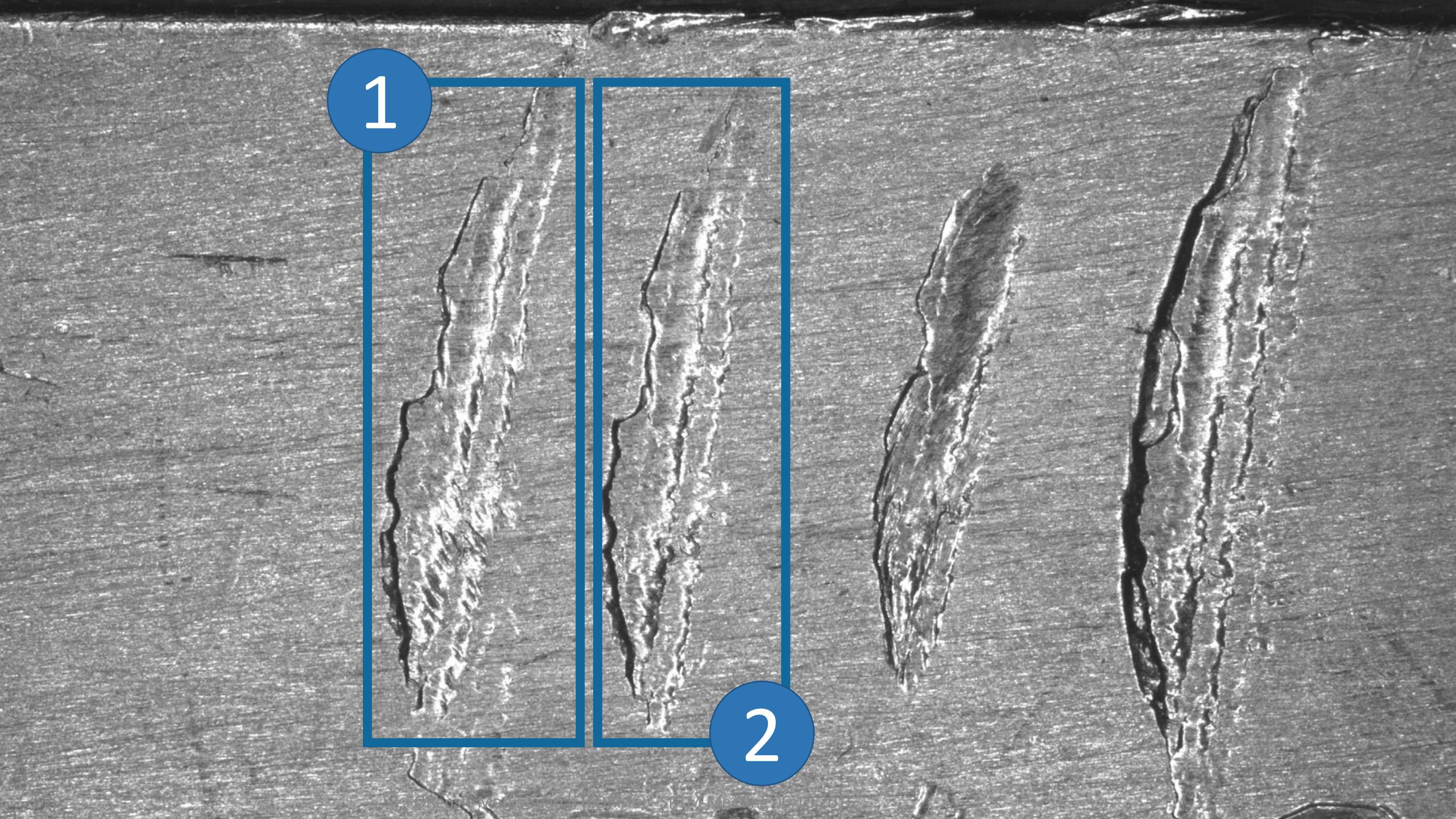
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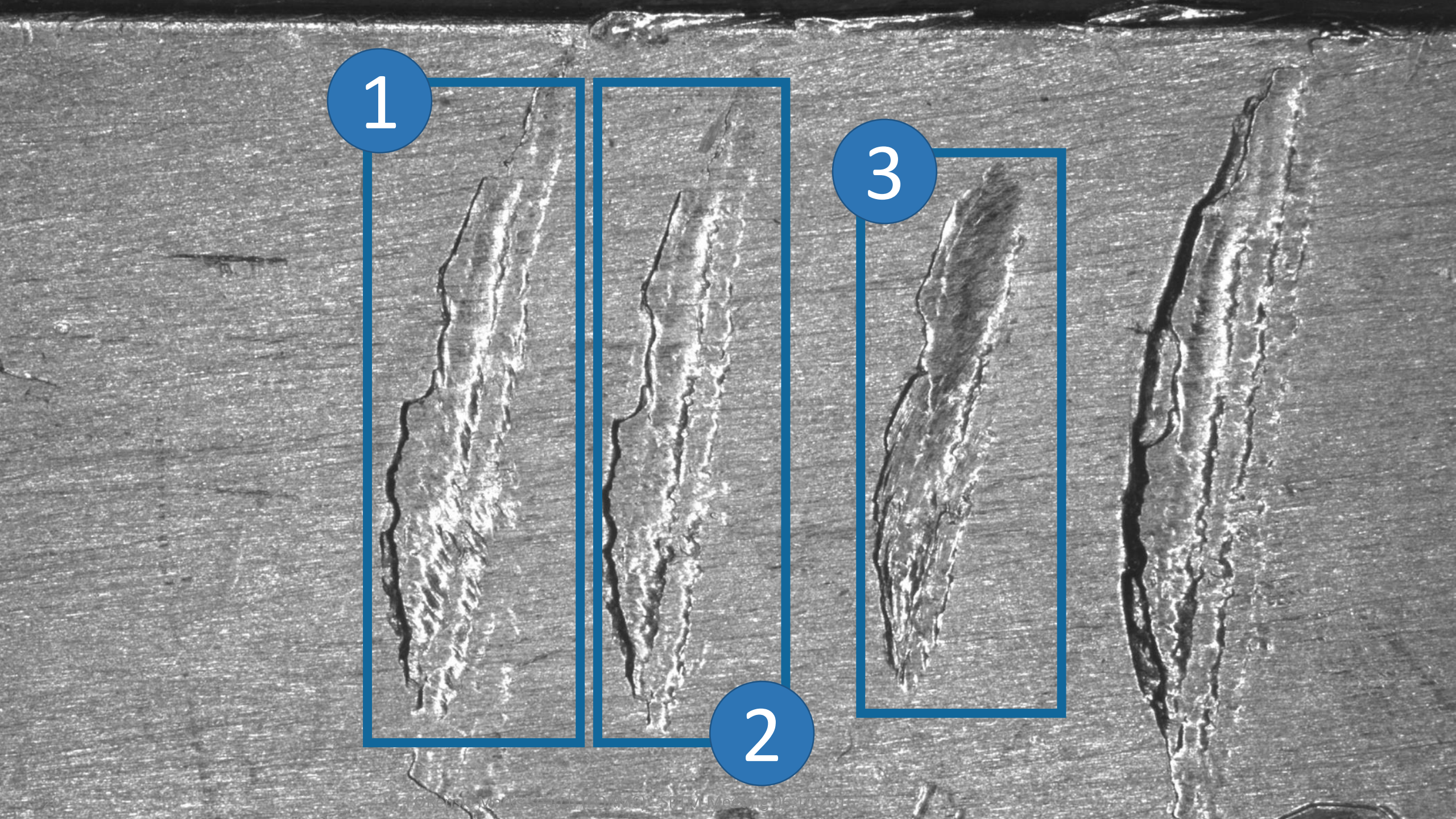
2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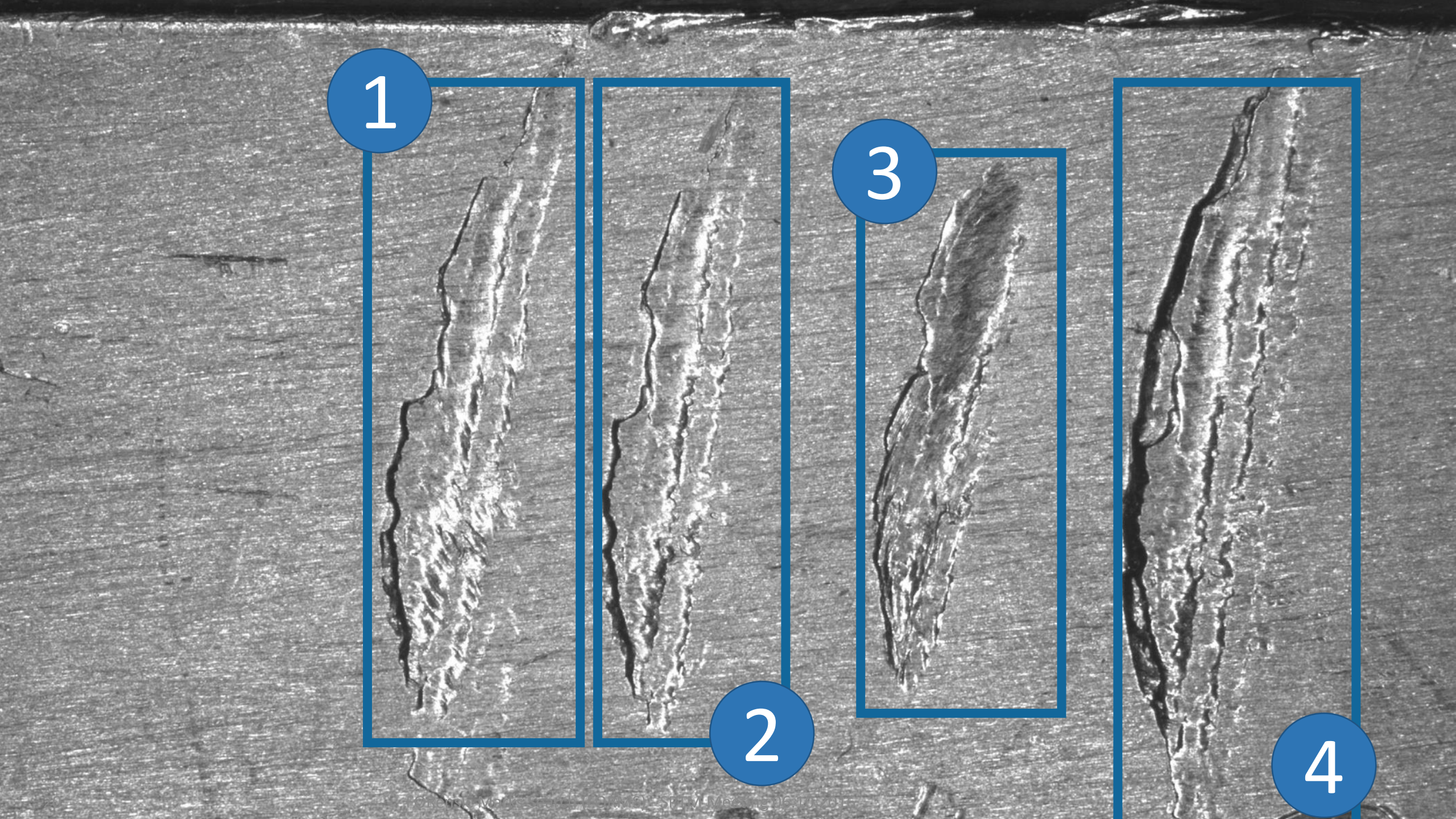
2
3


1
2
3
4

Methodology 〉Ground Truth

- Regions of Interest (ROI)
  - Multiple marks / image
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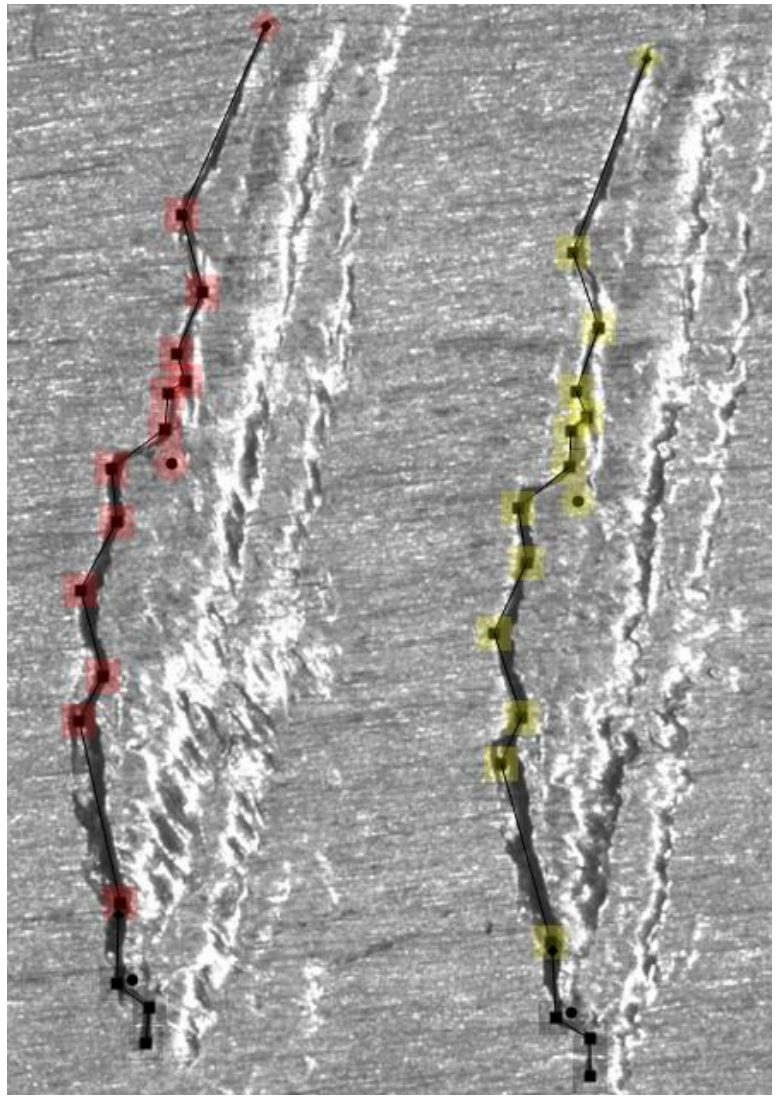
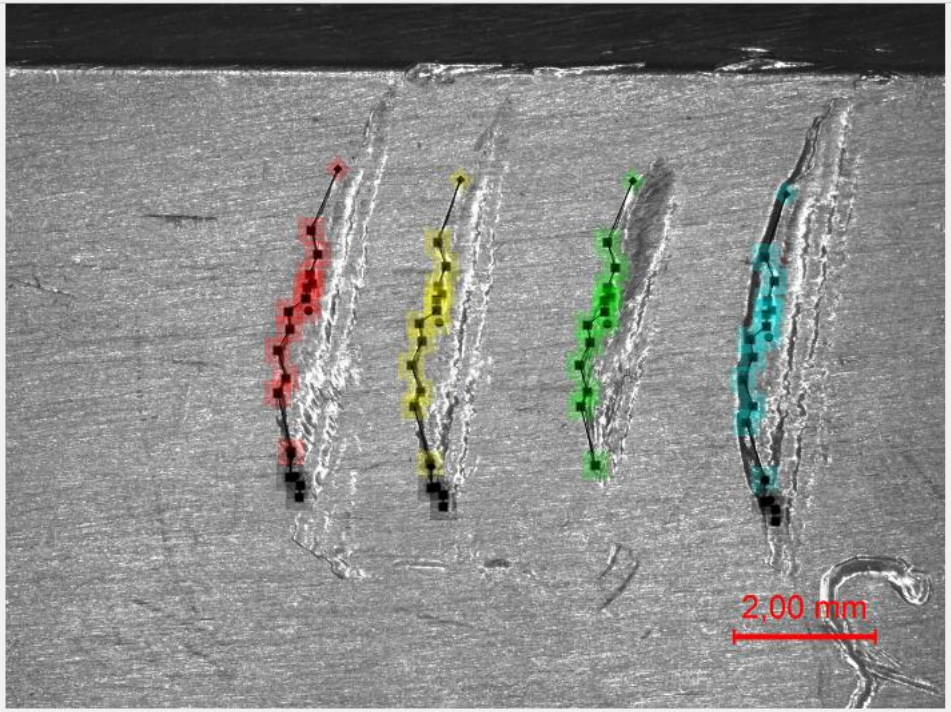
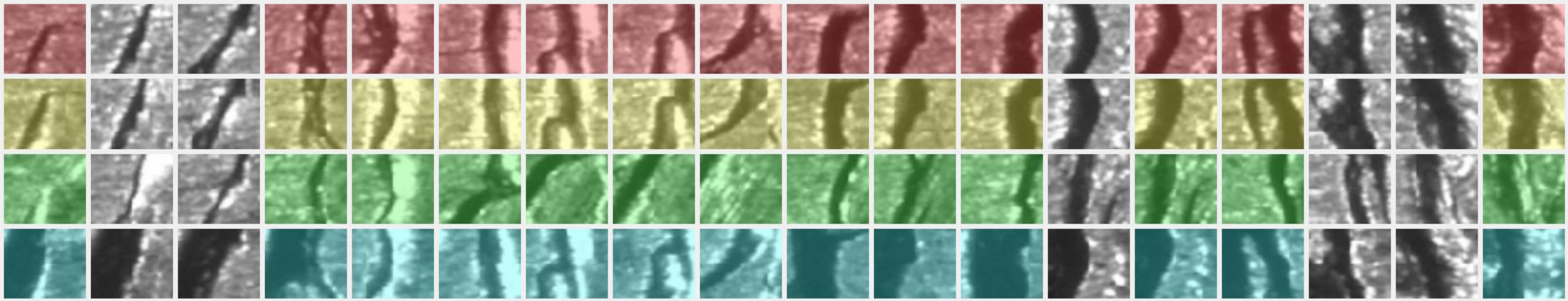


1615_13_A_W.jpg - 2592 x 1944

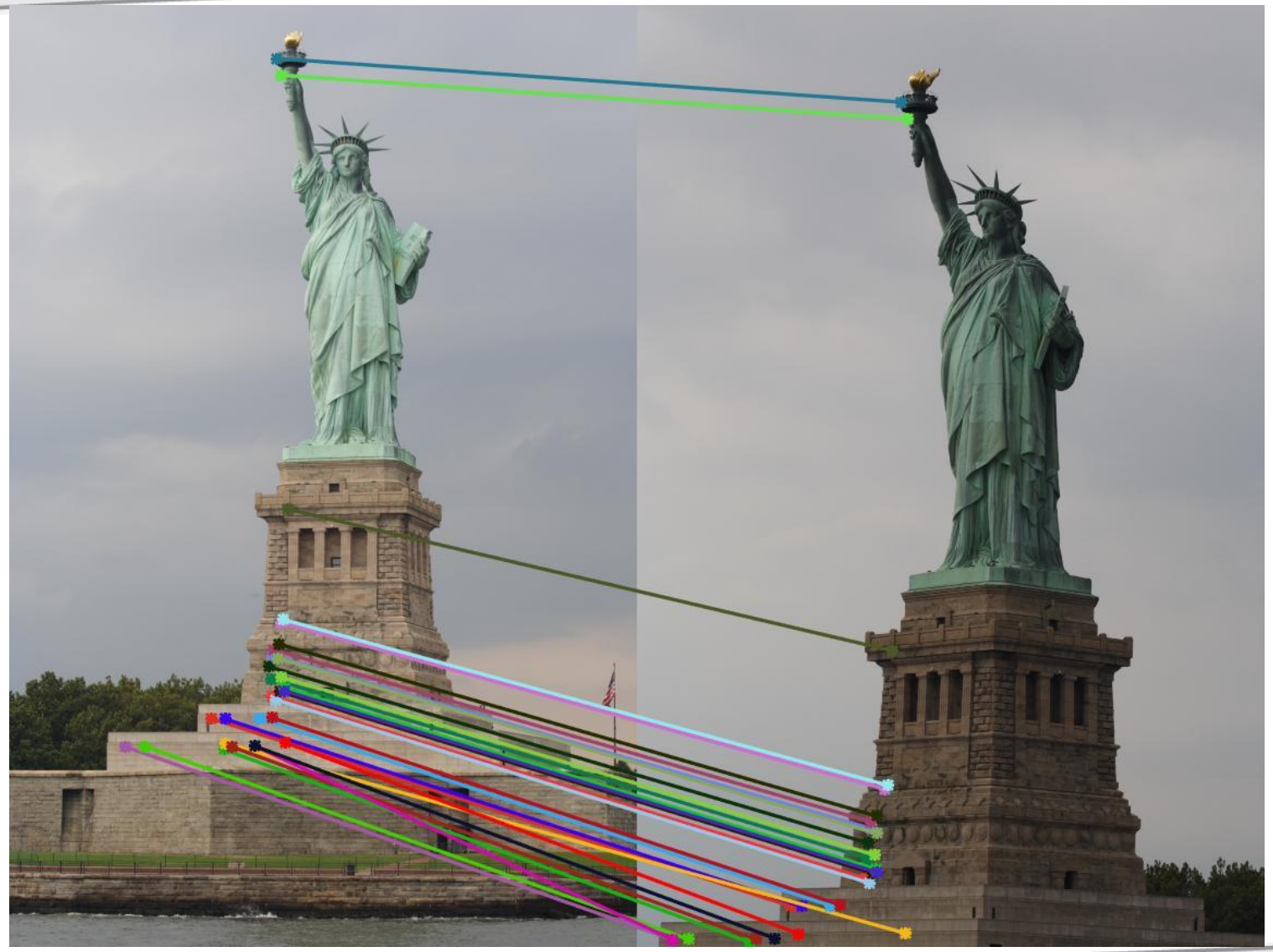
File Edit View Panels Tools Sync Plugins ?

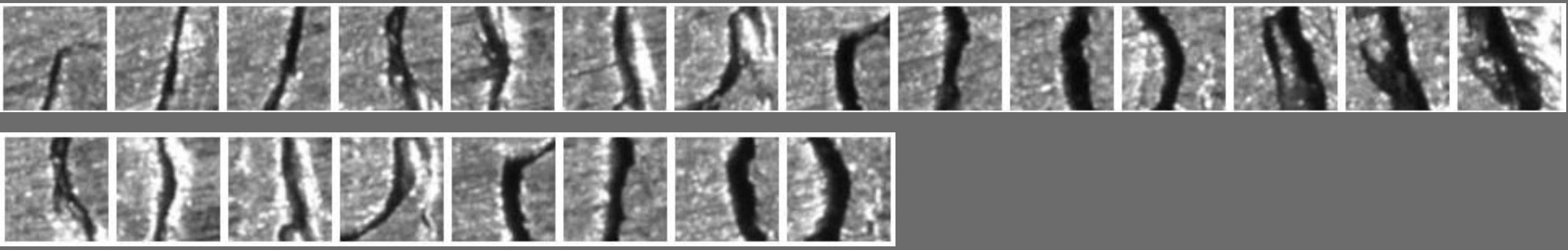
Timeline 7px Polygon Add Clone Remove Save Close



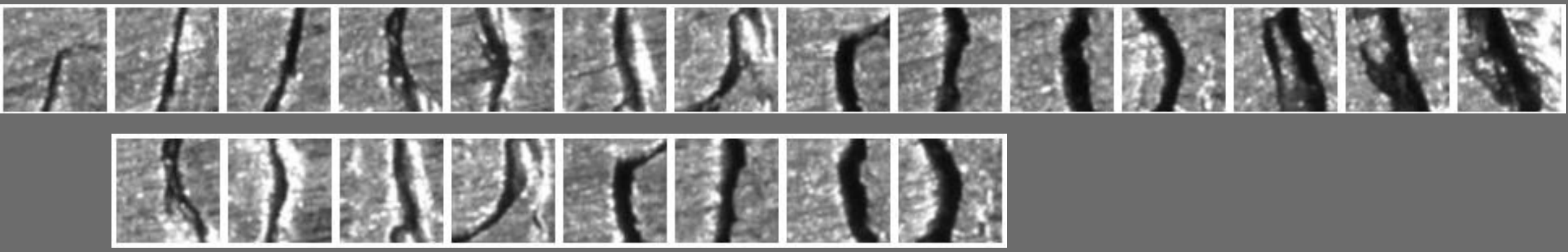


Deep Learning 〉Matching Patches

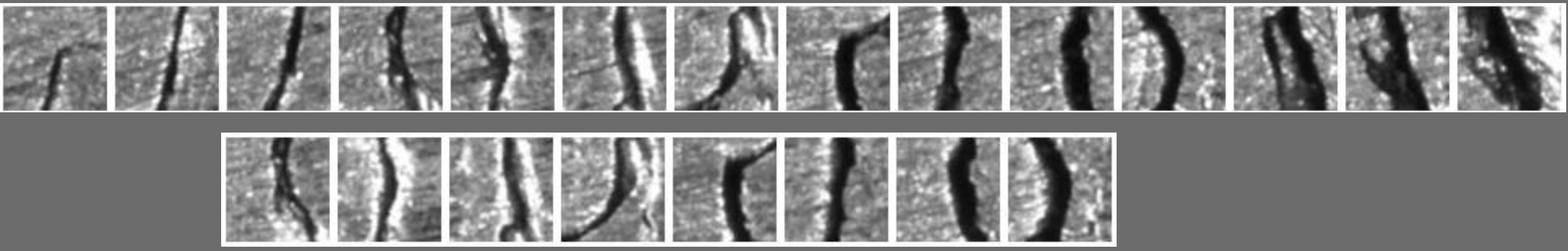




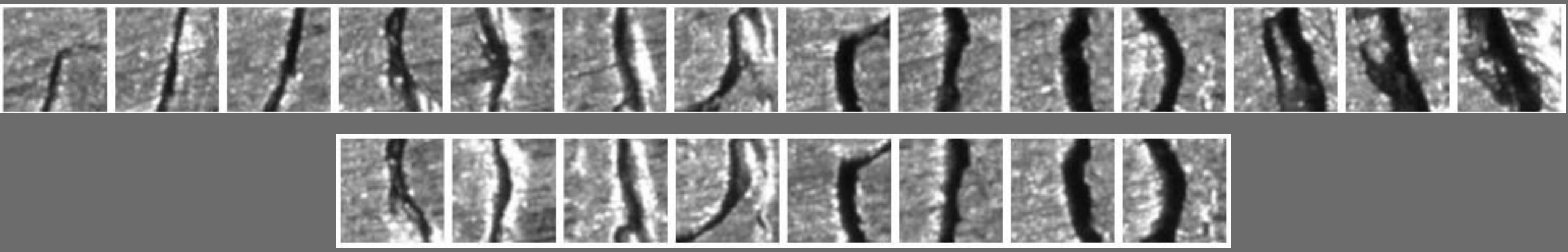
Methodology 〉 Polyline Matching



Methodology 〉 Polyline Matching



Methodology 〉 Polyline Matching

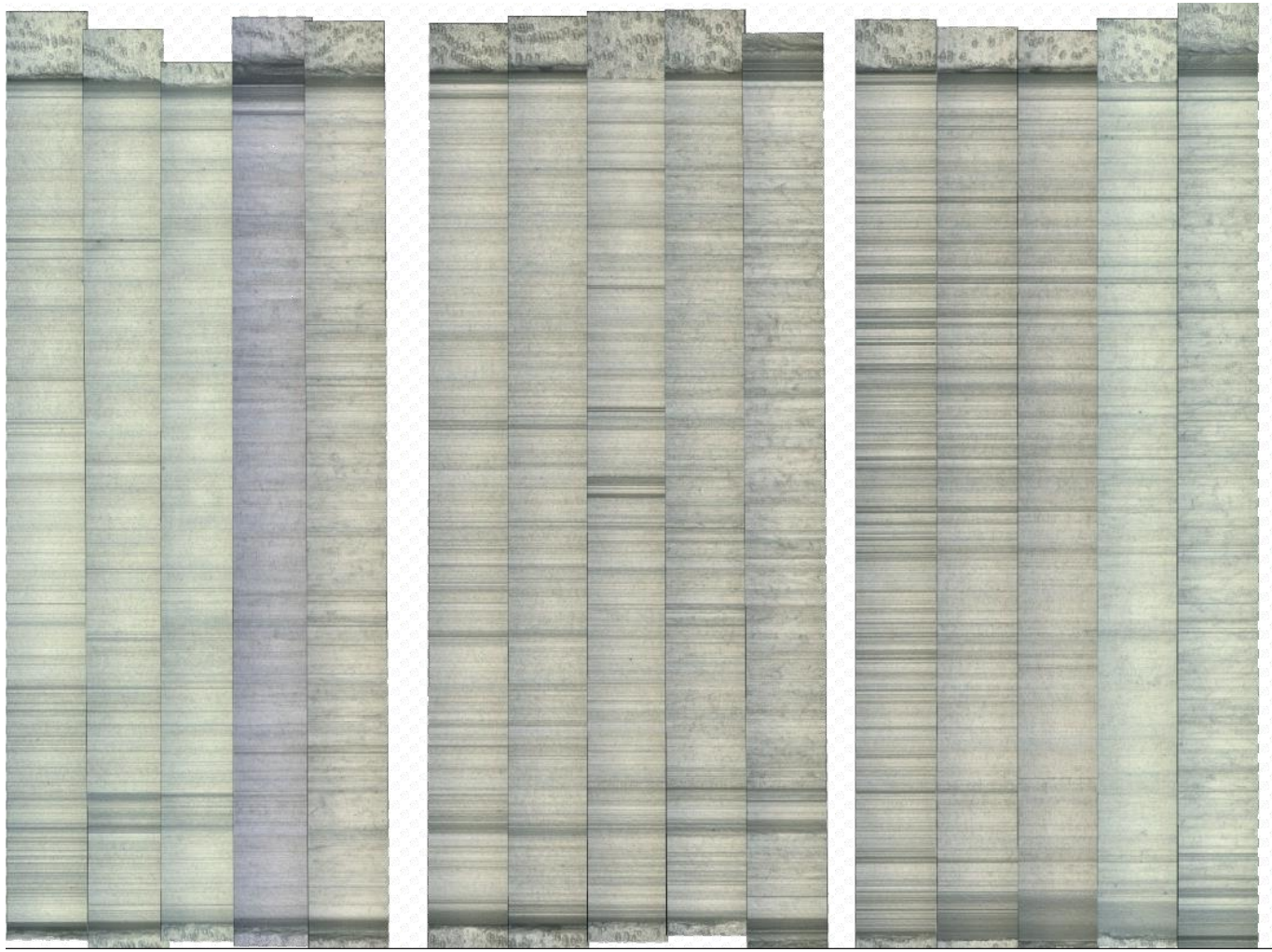


Methodology 〉 Polyline Matching

Results

Results 〉NFI Toolmark Database

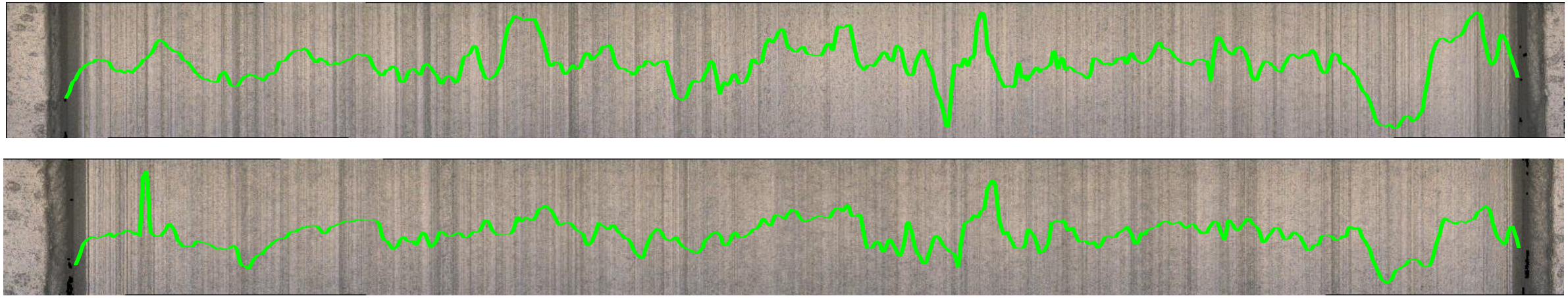
- Properties
  - 50 Screwdrivers (tool)
  - 5 angles of attack
  - 3D profiles & depth data
  - 2D high-res images(> 400x4000)
  - 300 images in total
- Advantages
  - Baseline results available [1]
  - Influence of resolution measureable
  - Comparison of 2D/3D possible



Baiker, M., Keereweer, I., Pieterman, R., Vermeij, E., van der Weerd, J. & Zoon, P., *Quantitative comparison of striated toolmarks,* **Forensic Science International**, 242, P.186-199, 2014

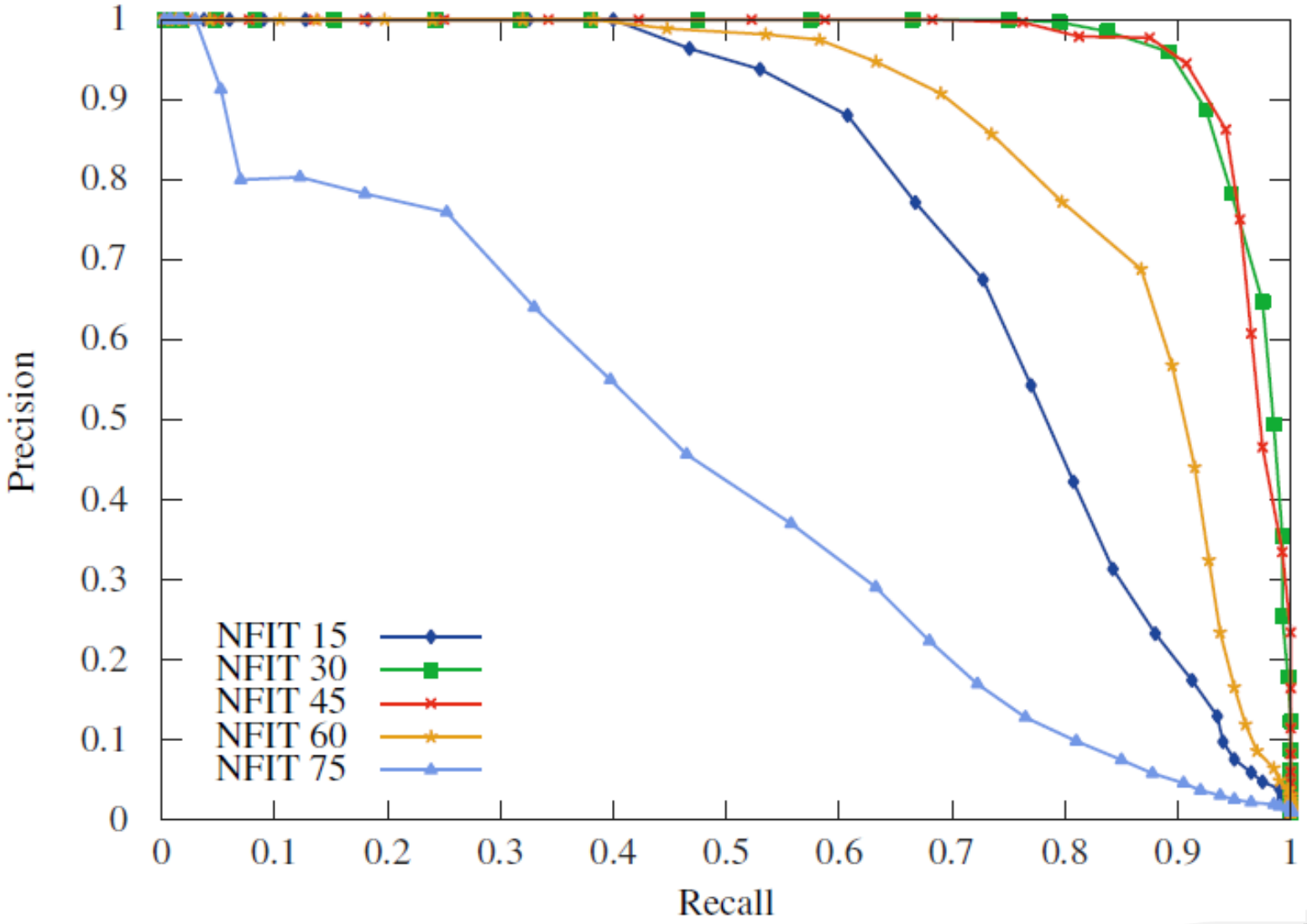
Results 〉NFI Toolmark Datenbank

- Example:
  - Same tool
  - 15° vs. 30°
  - 2D image / 3D profile superimposed



Results 〉NFI Toolmark Database

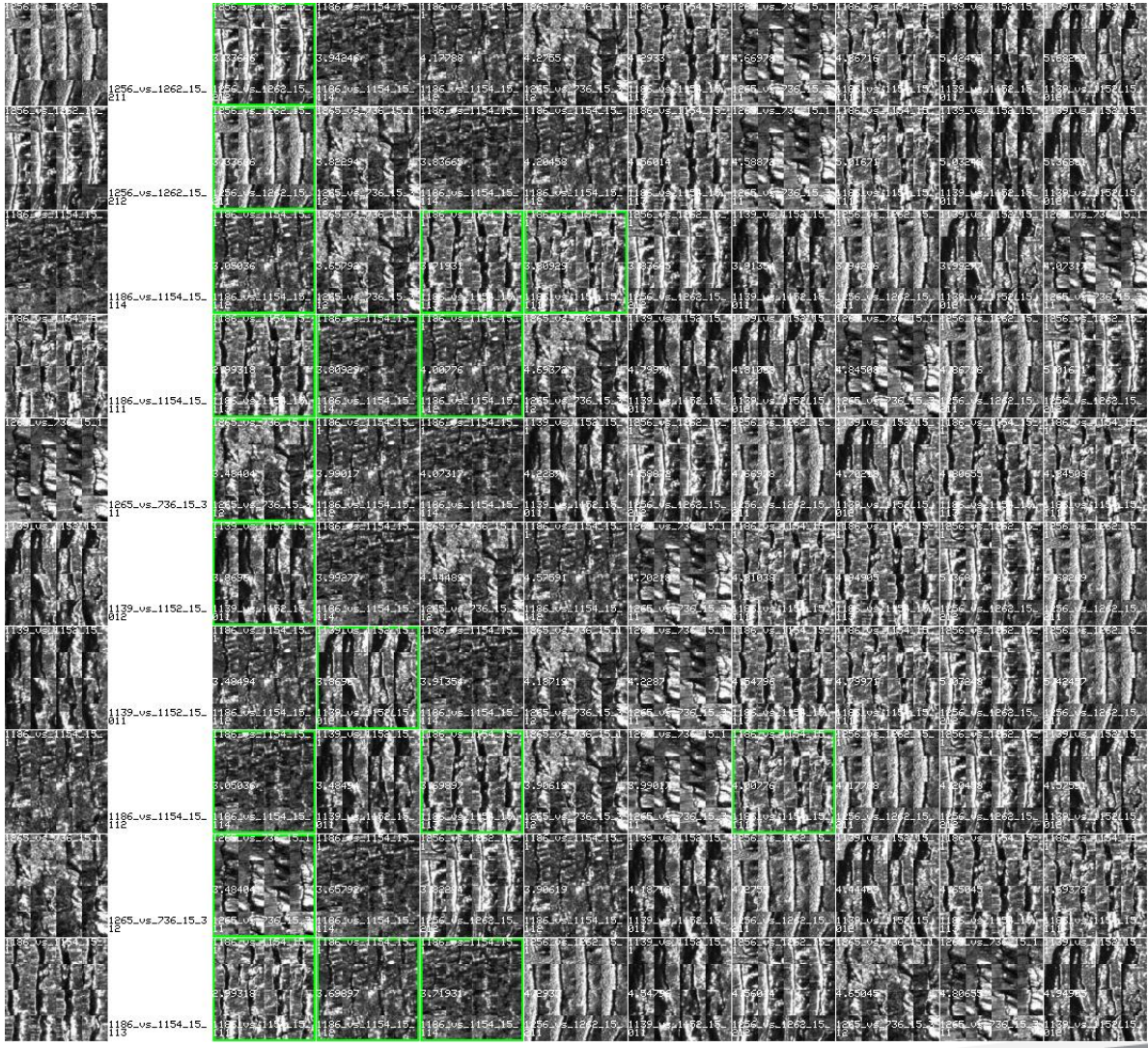
- NFIT 15
  - 15° test
  - 30°/45°/60°/75° train
  - MAP = 78%
- NFIT 30
  - 30° test
  - 15°/45°/60°/75° train
  - MAP = 95%



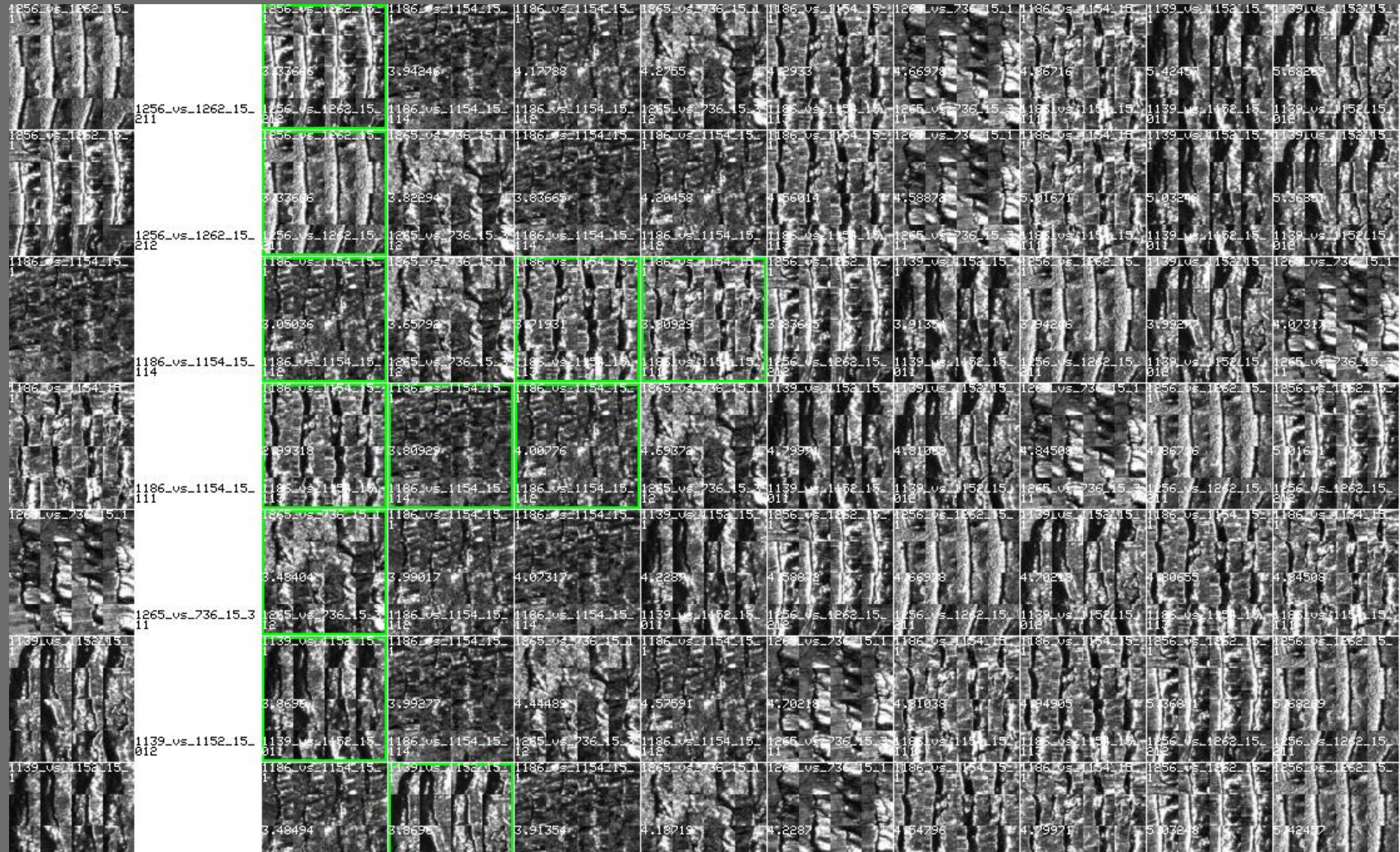
Results 〉FORMS

- Preliminary results
  - Trained with best sample images
  - Tested with small set of toolmarks (10) on different locks
  - MAP of about 90%

- @ Demo



Queries Ranked Results → (same tool)



Results
› FORMS

User Interface Demo

Next 〉FORMS Database

- Extend database
  - Same tool different locks
  - Varying (known) illumination

- We need YOUR toolmark images!

Requirements

- Resolution > 200 pixel / mm
- Multiple marks of same tool
- Type of tool annotated
- Scale annotated (or fixed)

mkeglevic@caa.tuwien.ac.at

nomacs
Image Lounge
www.nomacs.org

Thank you!