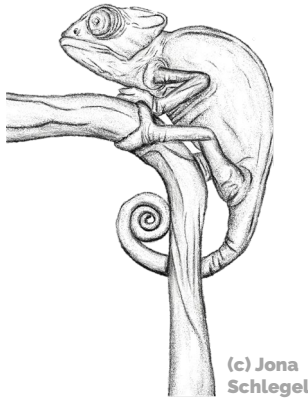


TRACKING THE URBAN CHAMELEON – TOWARDS A HYBRID CHANGE DETECTION OF GRAFFITI

Benjamin Wild, Geert Verhoeven, and Norbert Pfeifer

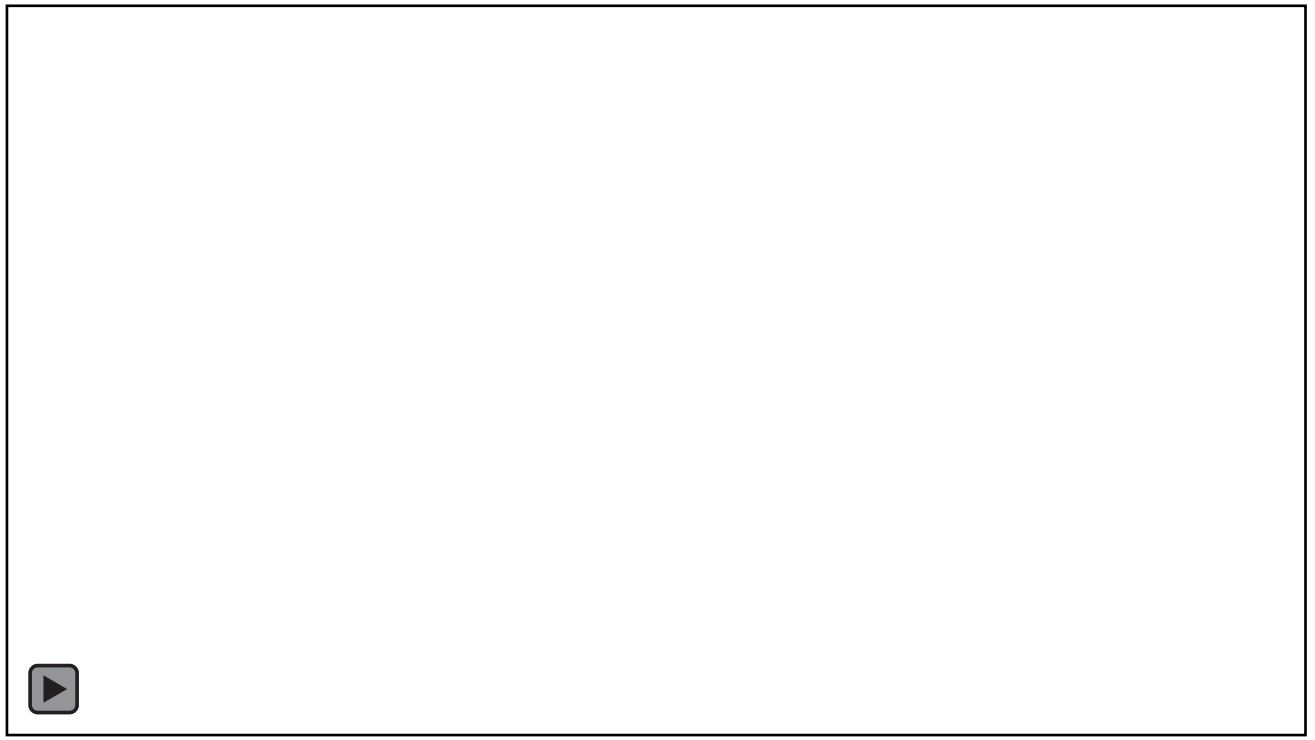
The INDIGO graffiti project is funded by the Heritage Science Austria programme of the Austrian Academy of Sciences (ÖAW)

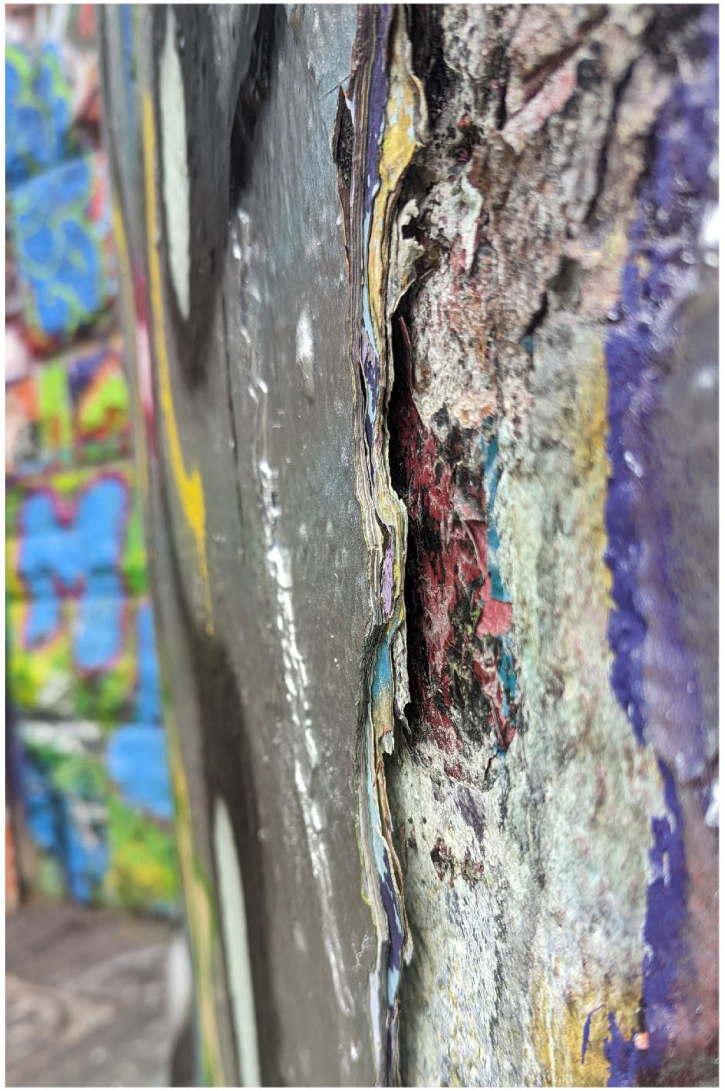
indigo

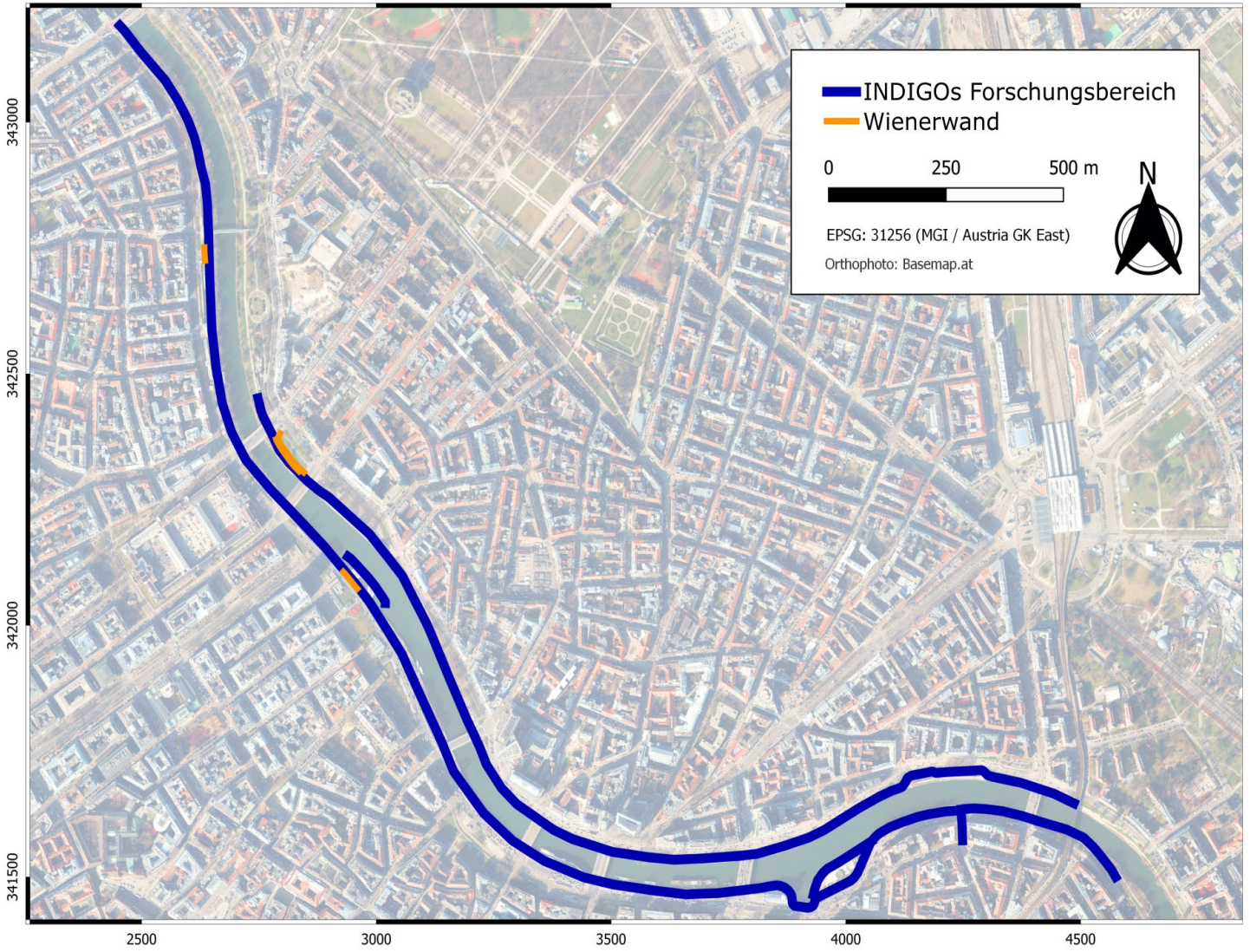
inventory and disseminate graffiti along the donaukanal

AUTOGRAF COOLPIX GRAPHIS

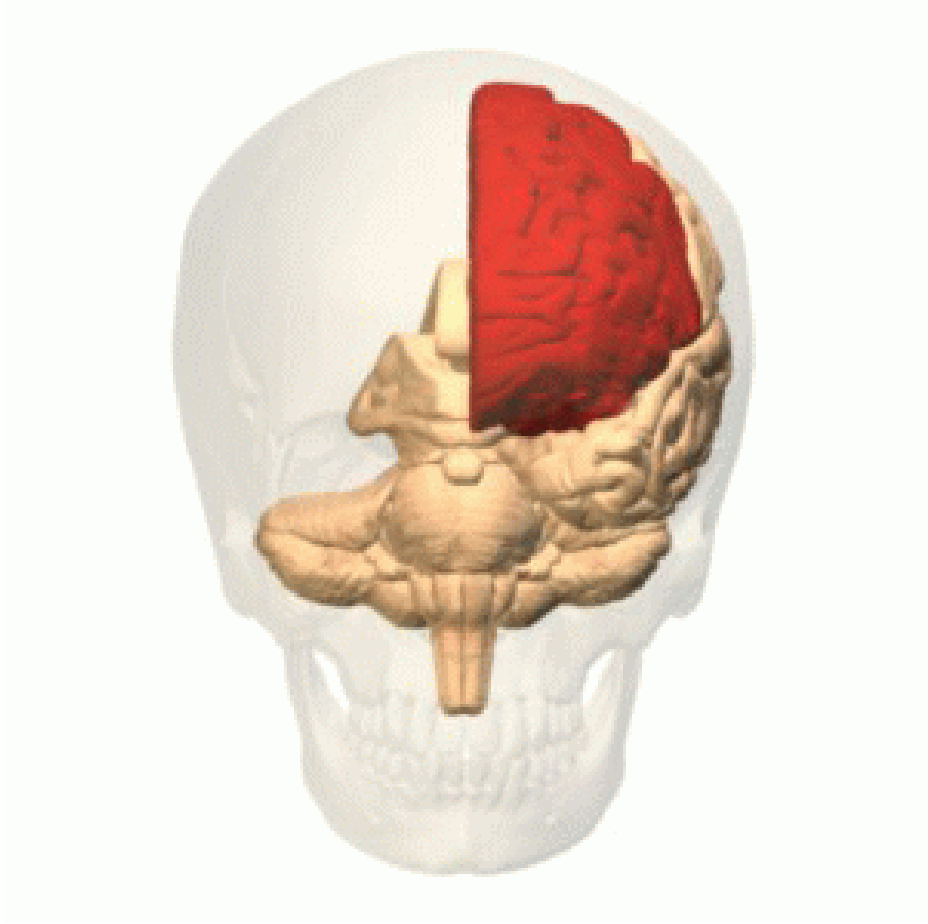
github.com/GraffitiProjectINDIGO





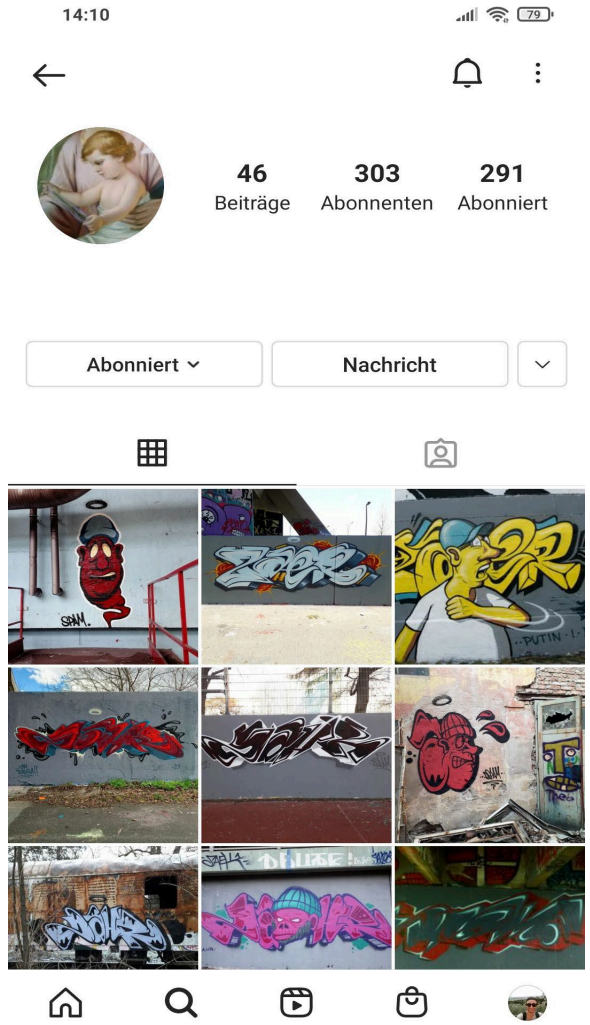

INDIGOs Forschungsbereich
Wienerwand
0
250
500 m
N
EPSG: 31256 (MGI / Austria GK East)
Orthophoto: Basemap.at
343000
342500
342000
341500
2500
3000
3500
4000
4500

Monitoring so far



Life Science Databases (CC-BY-SA)

+



#INDIGODonaukanal

Aim

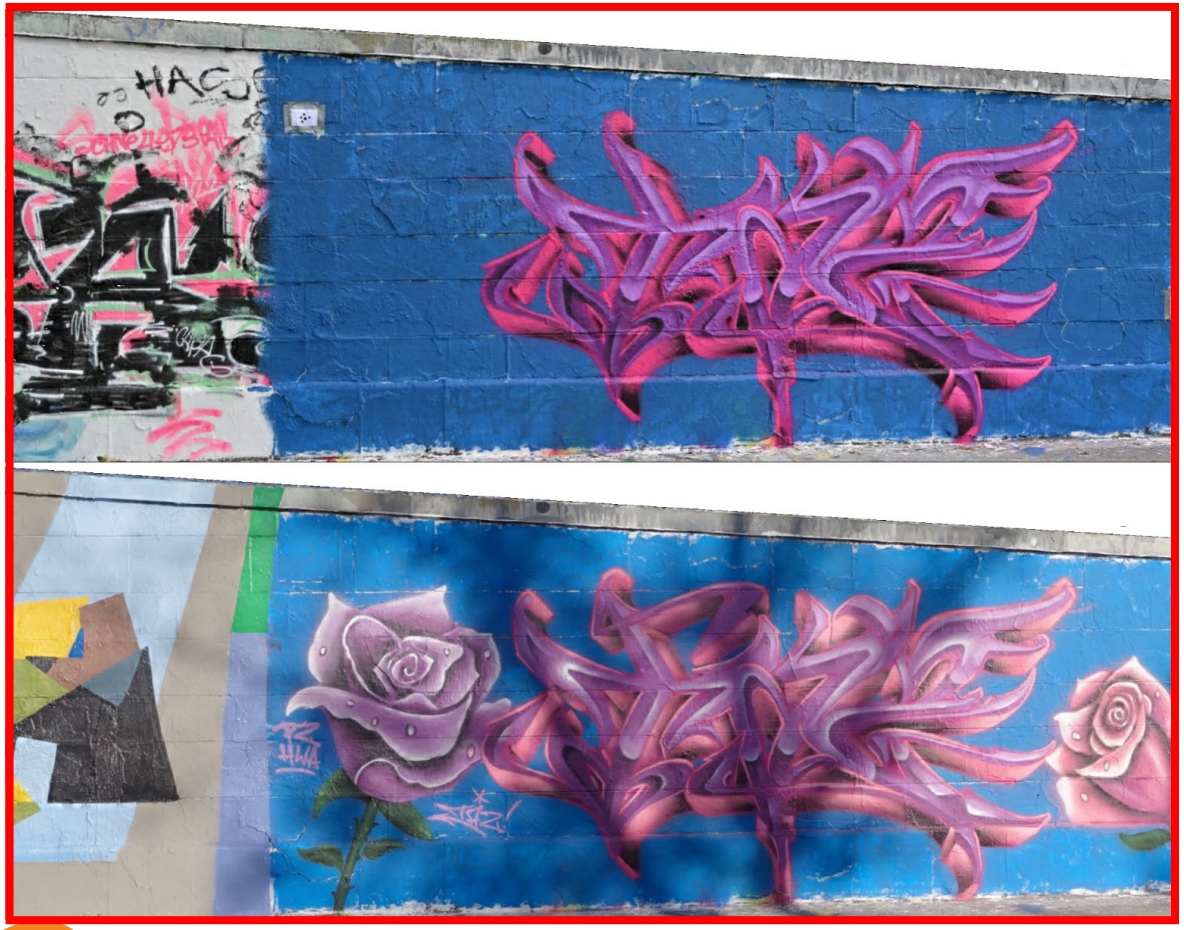
Automated change detection

Aim

Aim

Aim

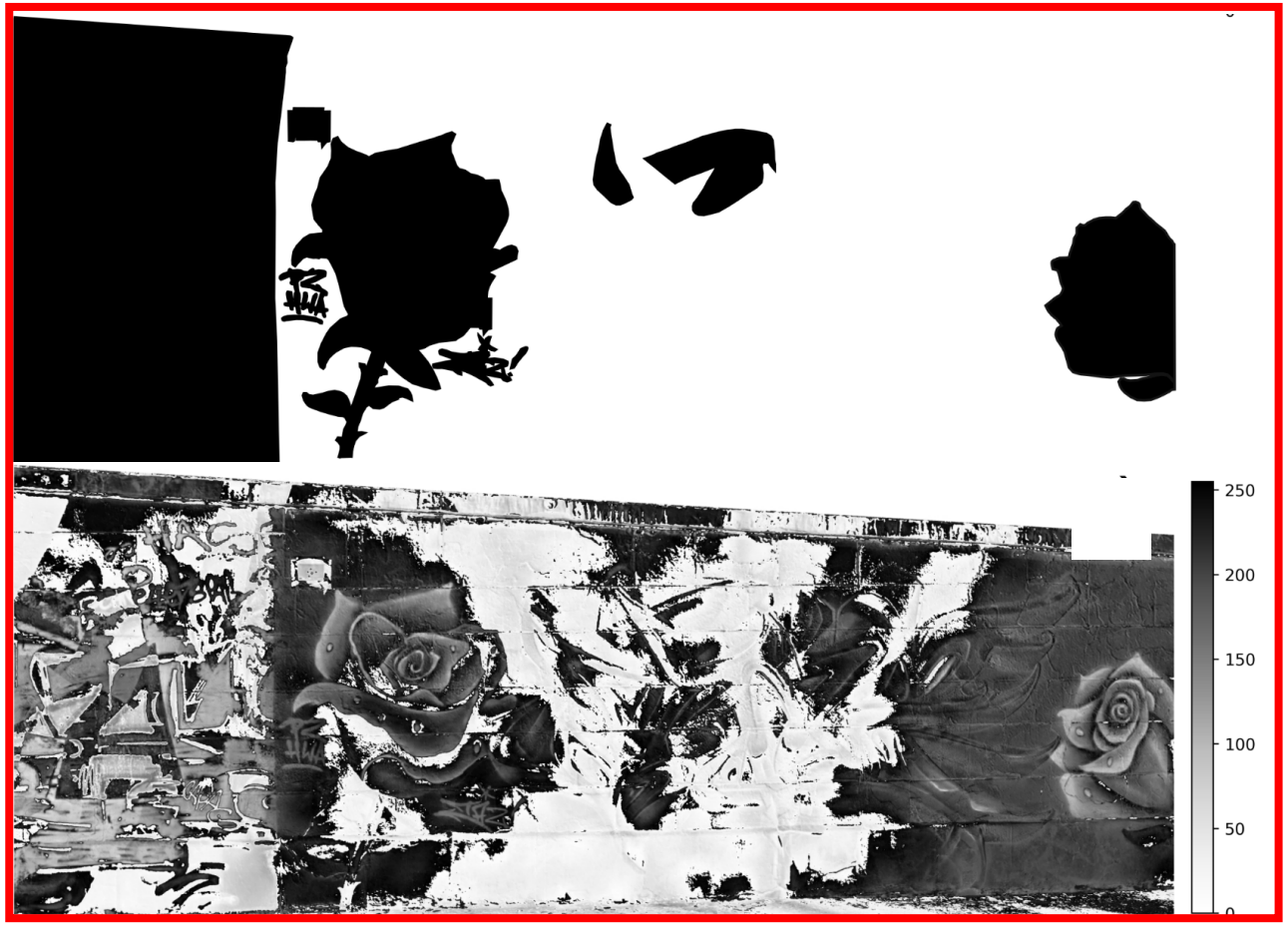
Challenge 1



Aim

Challenge 1

Challenge 2



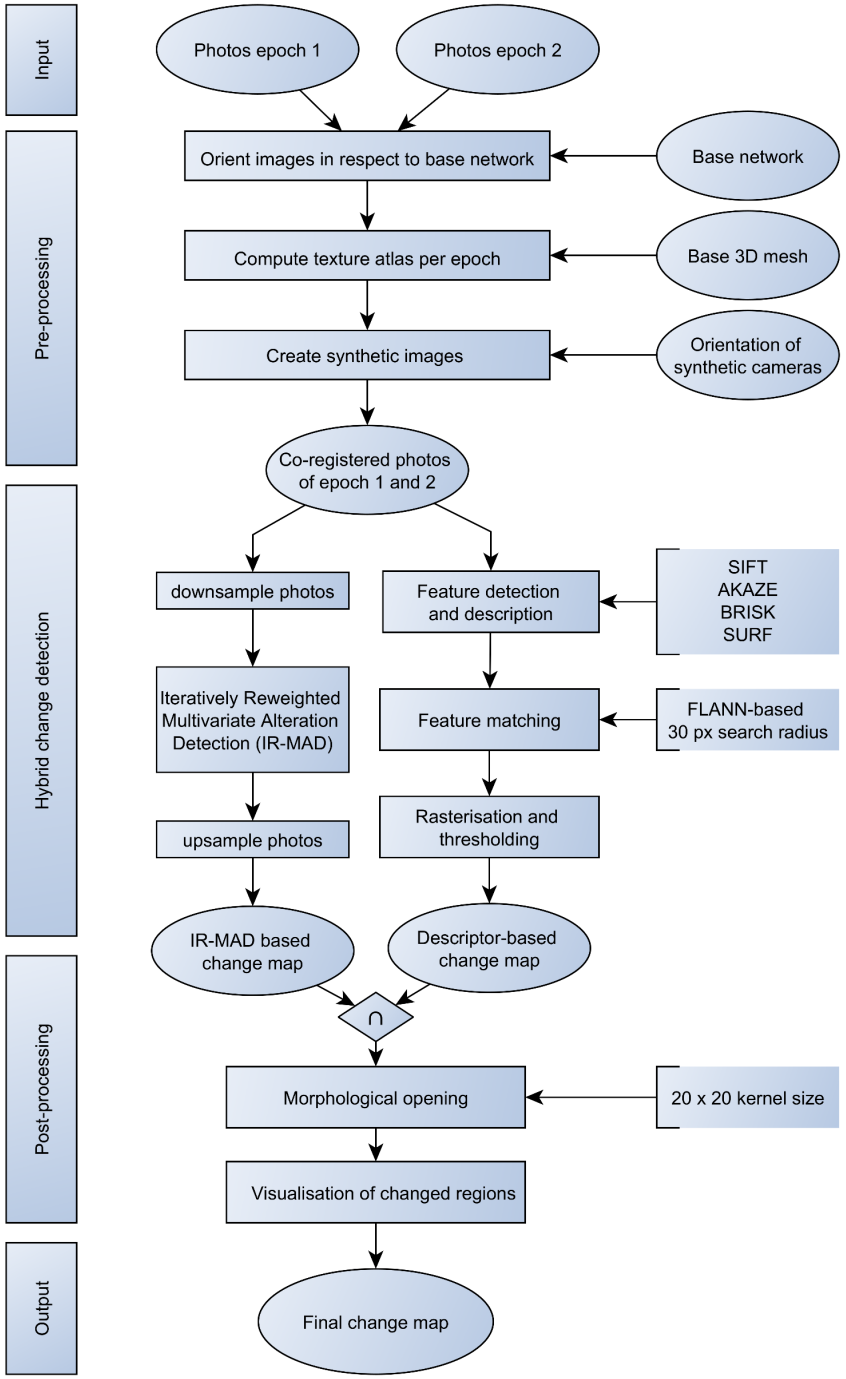

Input
Pre-processing
Hybrid change detection
Post-processing
Output
Photos epoch 1
Photos epoch 2
Orient images in respect to base network
Base network
Compute texture atlas per epoch
Base 3D mesh
Create synthetic images
Orientation of synthetic cameras
Co-registered photos of epoch 1 and 2
downsample photos
Feature detection and description
SIFT
AKAZE
BRISK
SURF
Iteratively Reweighted Multivariate Alteration Detection (IR-MAD)
Feature matching
FLANN-based
30 px search radius
upsample photos
Rasterisation and thresholding
IR-MAD based change map
Descriptor-based change map
∩
Morphological opening
20 x 20 kernel size
Visualisation of changed regions
Final change map

Image acquisition

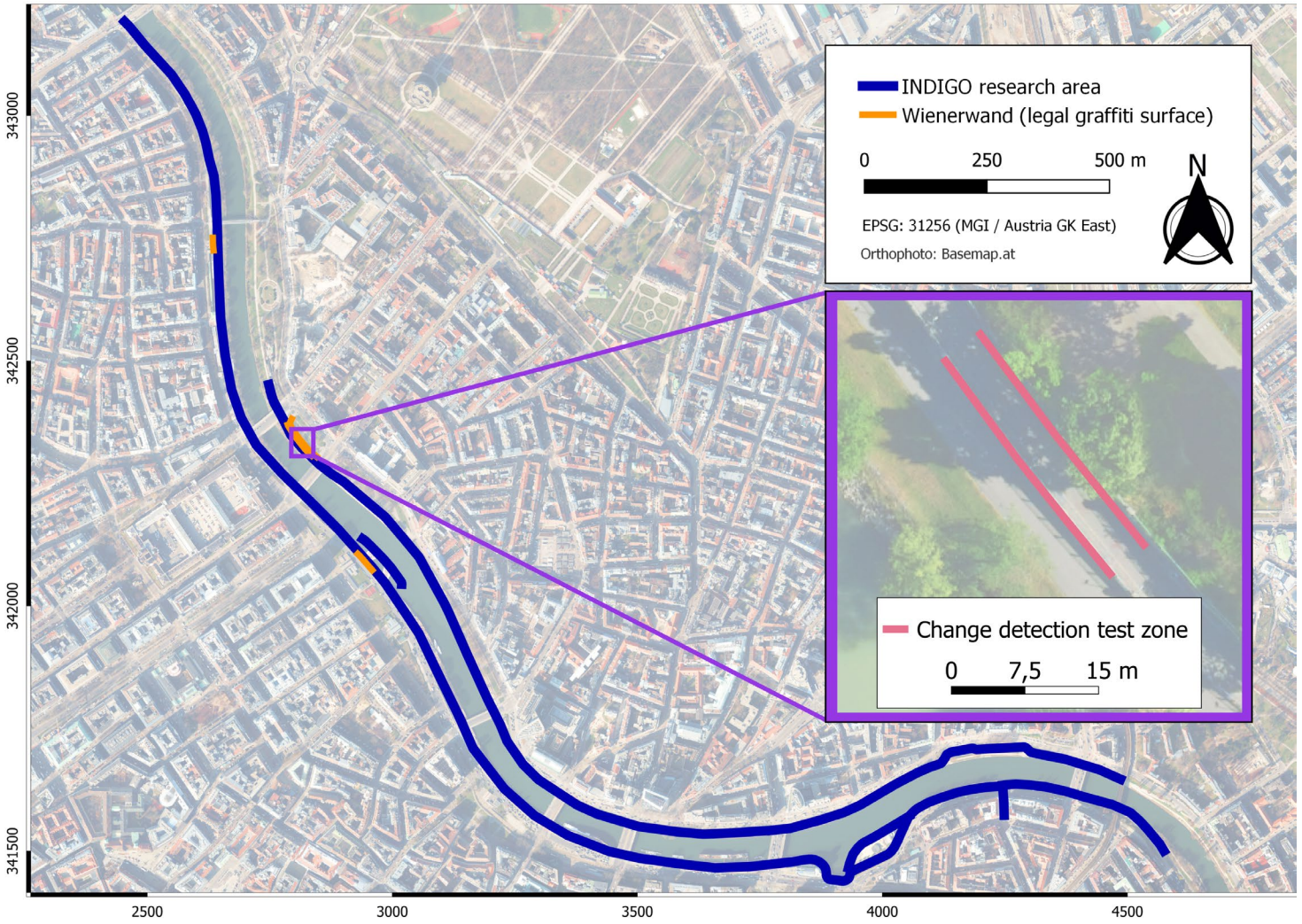


Image acquisition

Image acquisition

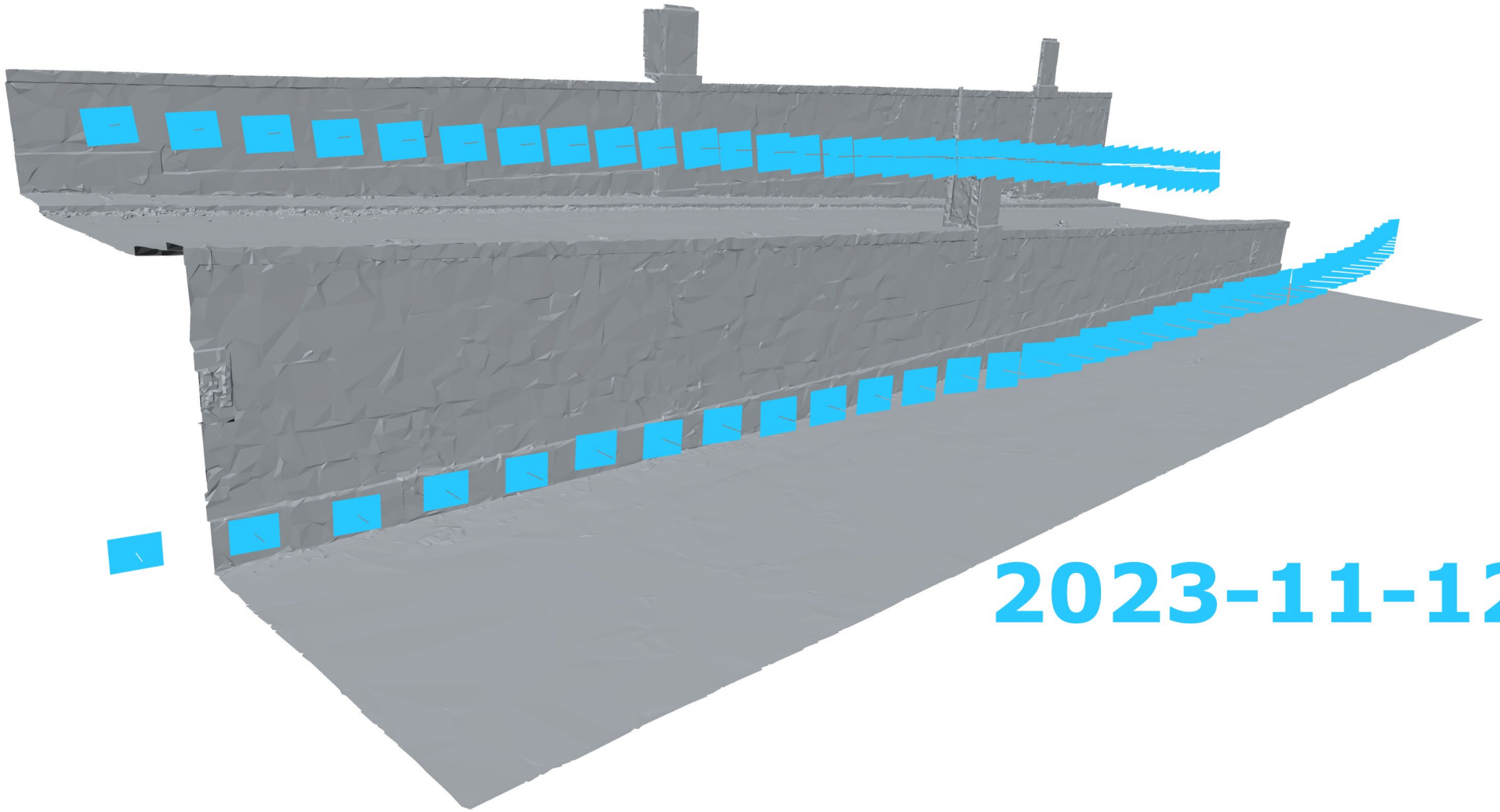
Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

29 acquisitions in total

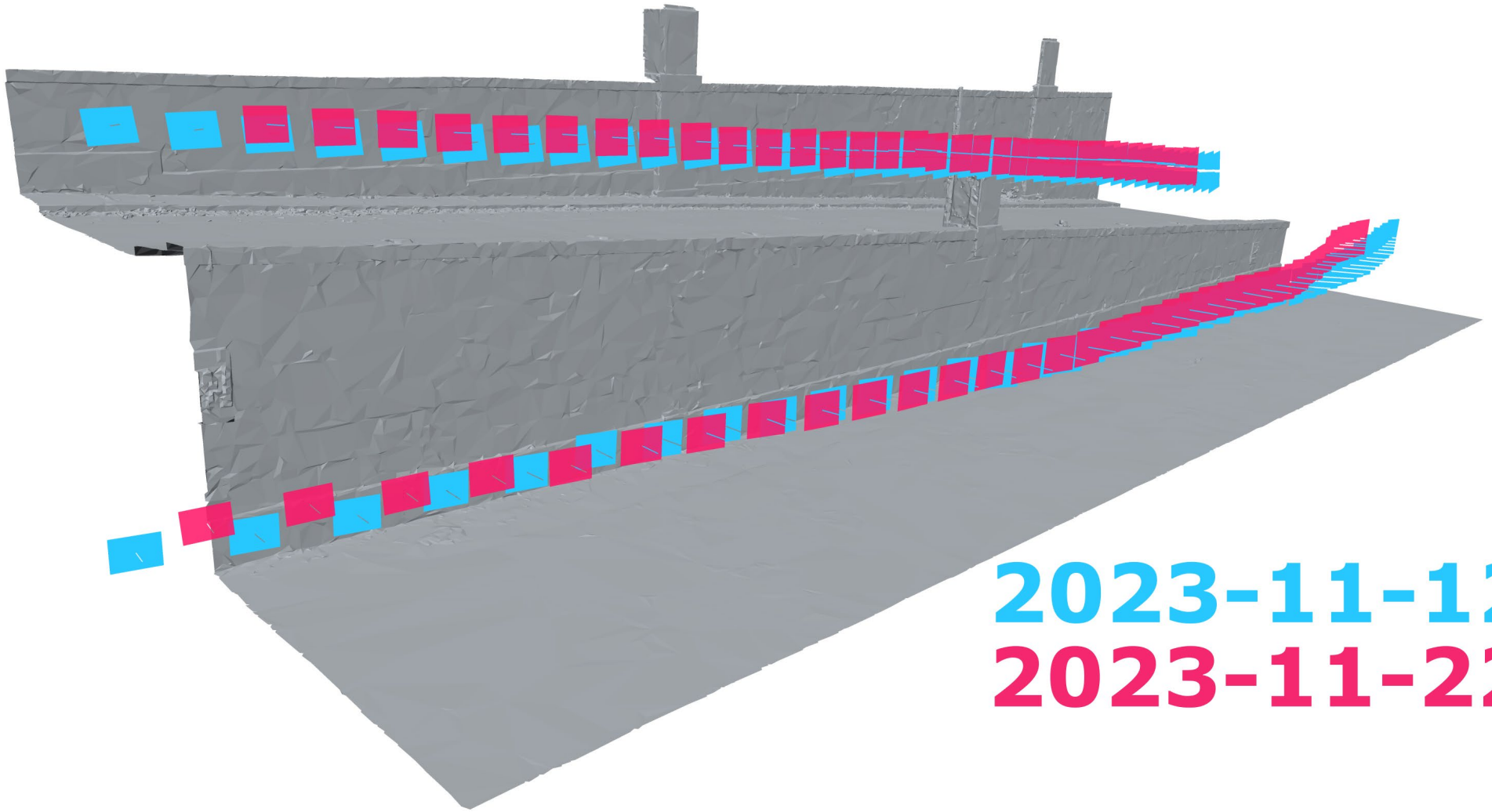
Image acquisition

Pre-processing / co-registration

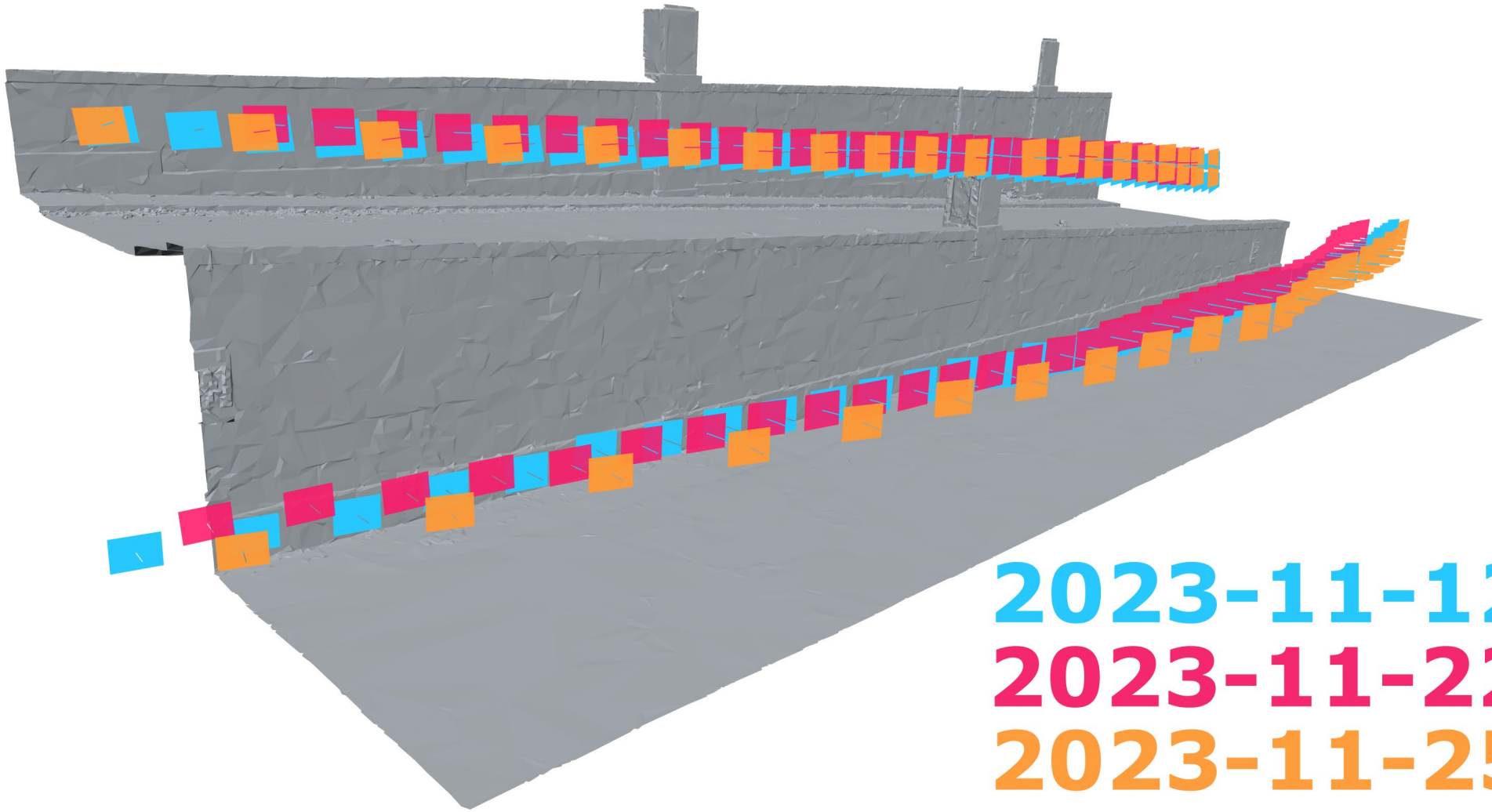
Co-registration



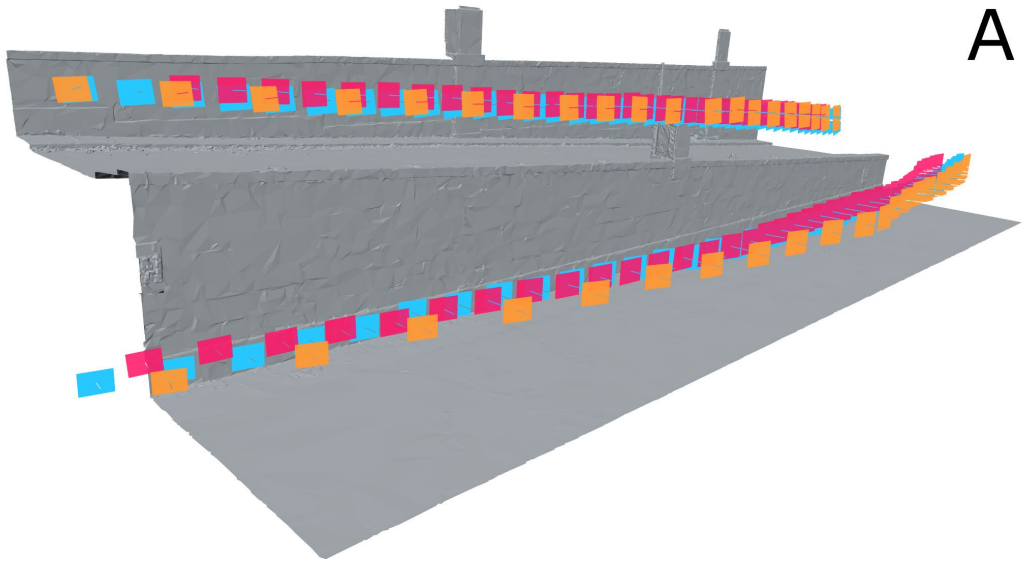
Co-registration



Co-registration



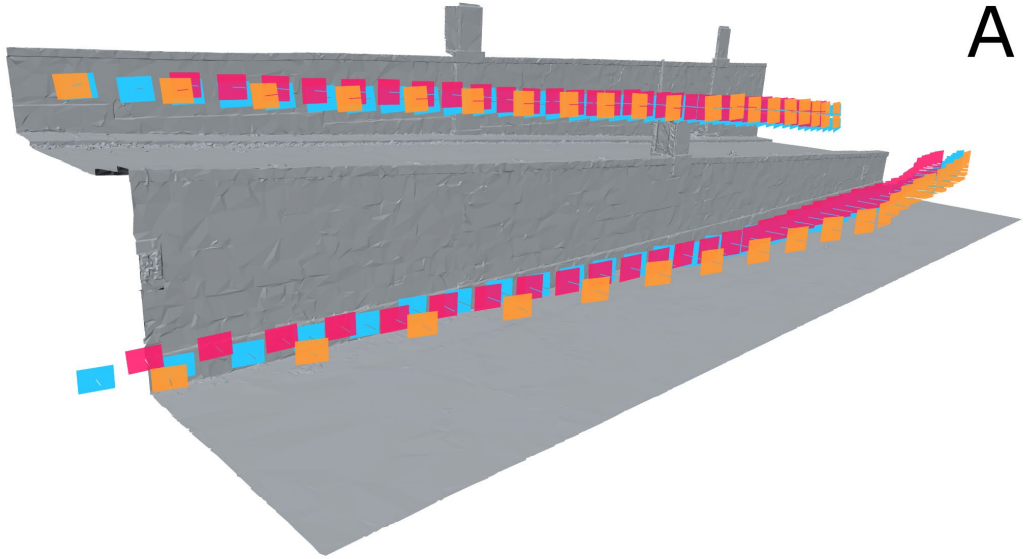
Co-registration



A

18

Co-registration



A

B

2023-11-12

C

2023-11-22

D

2023-11-25

Co-registration

2022-10-21_Z7ii-A

Co-registration

Co-registration


MIRIAM
REINI REINI REINI REINI REIN
22


HARRY STYLES

2022-10-21_Z7ii-A

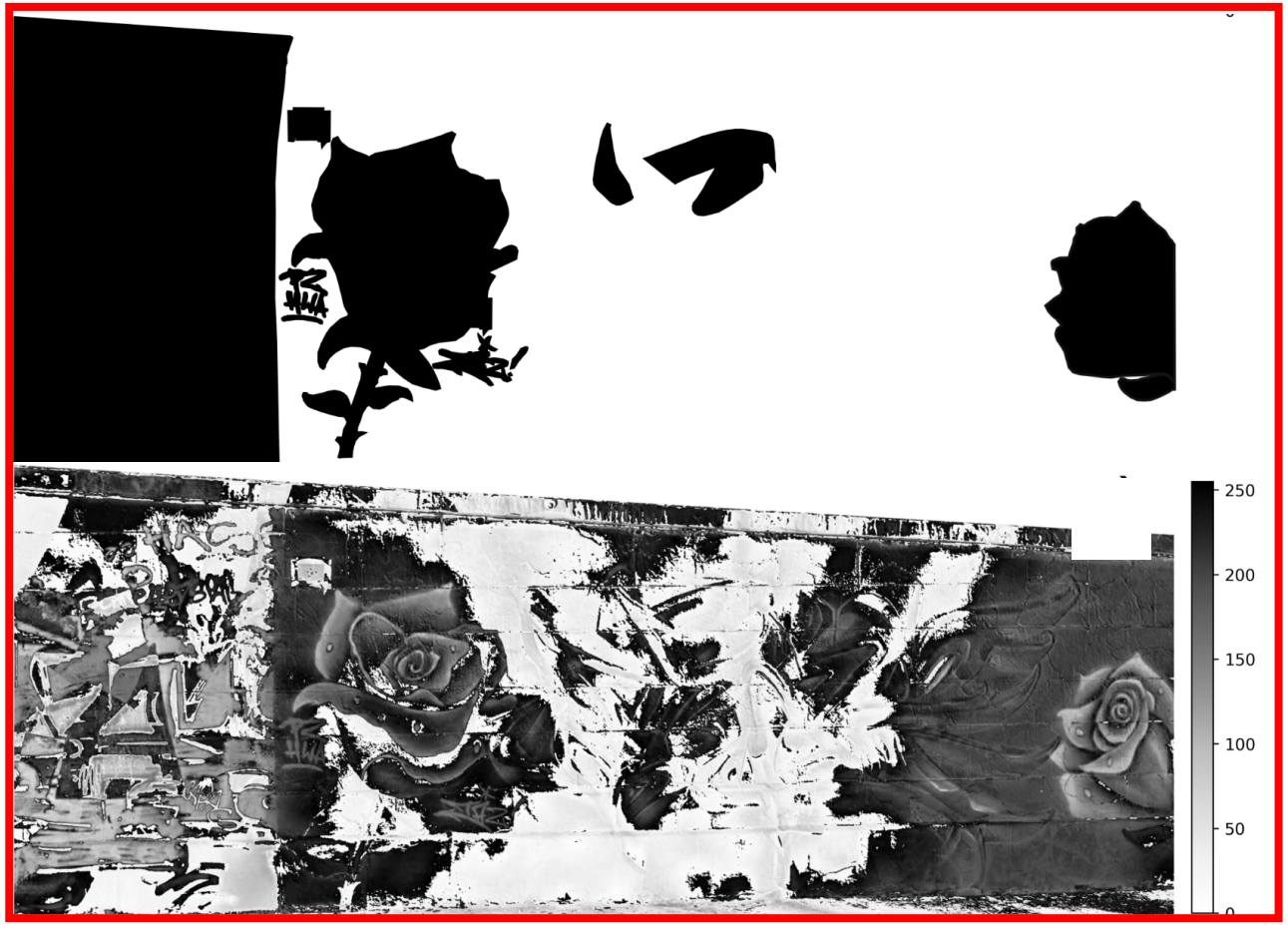
Result from one synthetic cameras

17 Synthetic cameras ✖ **29** Acquisitions = **493** Synthetic Images

Aim

Challenge 1

Challenge 2



Hybrid change detection

IR-MAD

Descriptor-Based

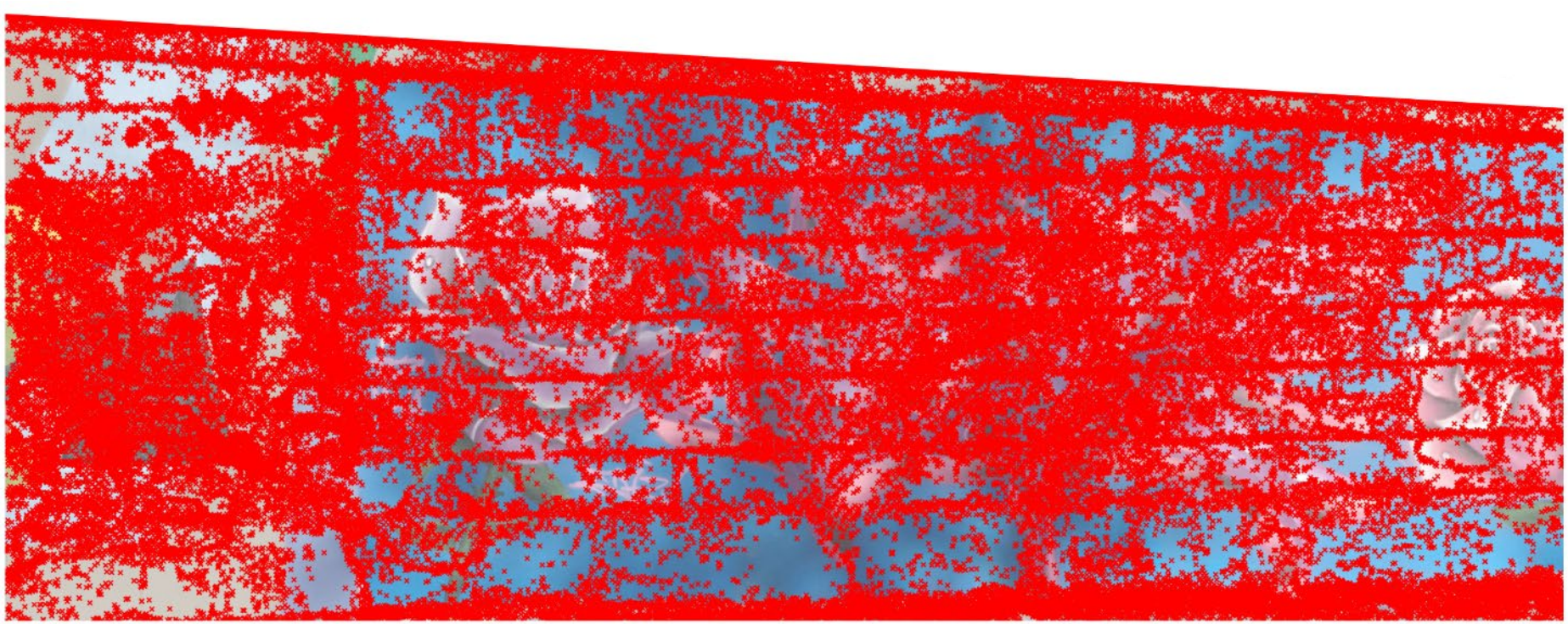
AND

IR-MAD

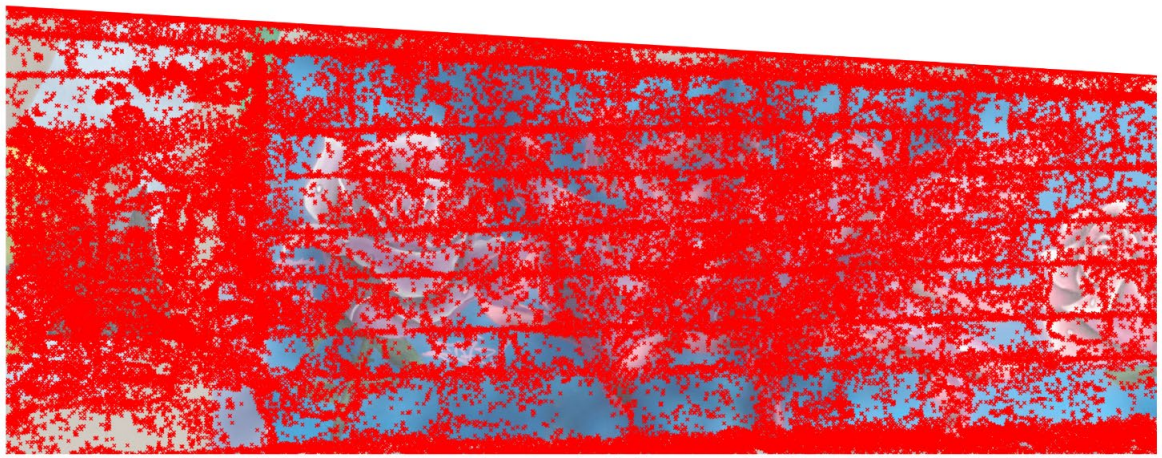
Iteratively Reweighted Multivariate Alteration Detection (IRMAD; Nielsen 2007)

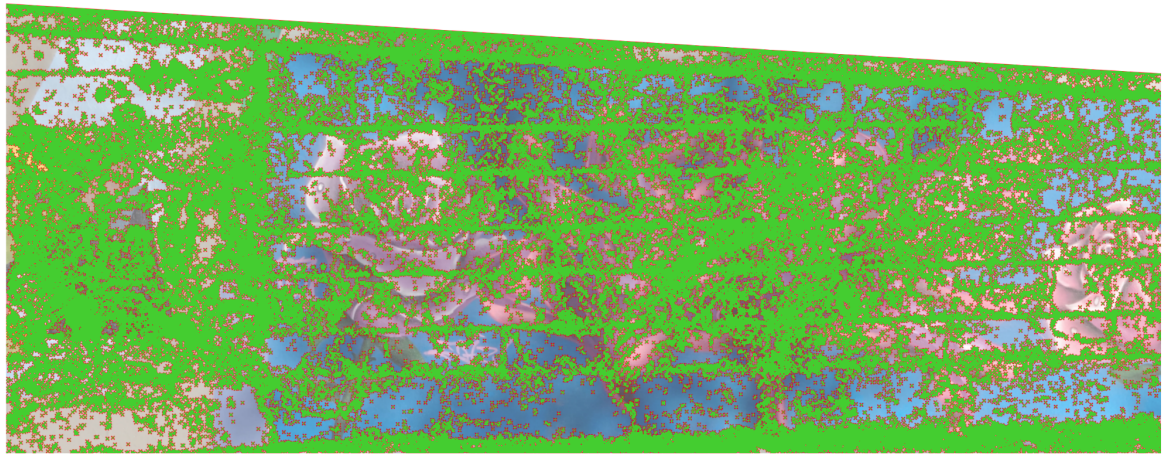
- detects uncorrelated information between the input images → change
- invariant to linear scaling and illumination
- noisy results and difficulties in entirely unchanged scenes

Descriptor-Based



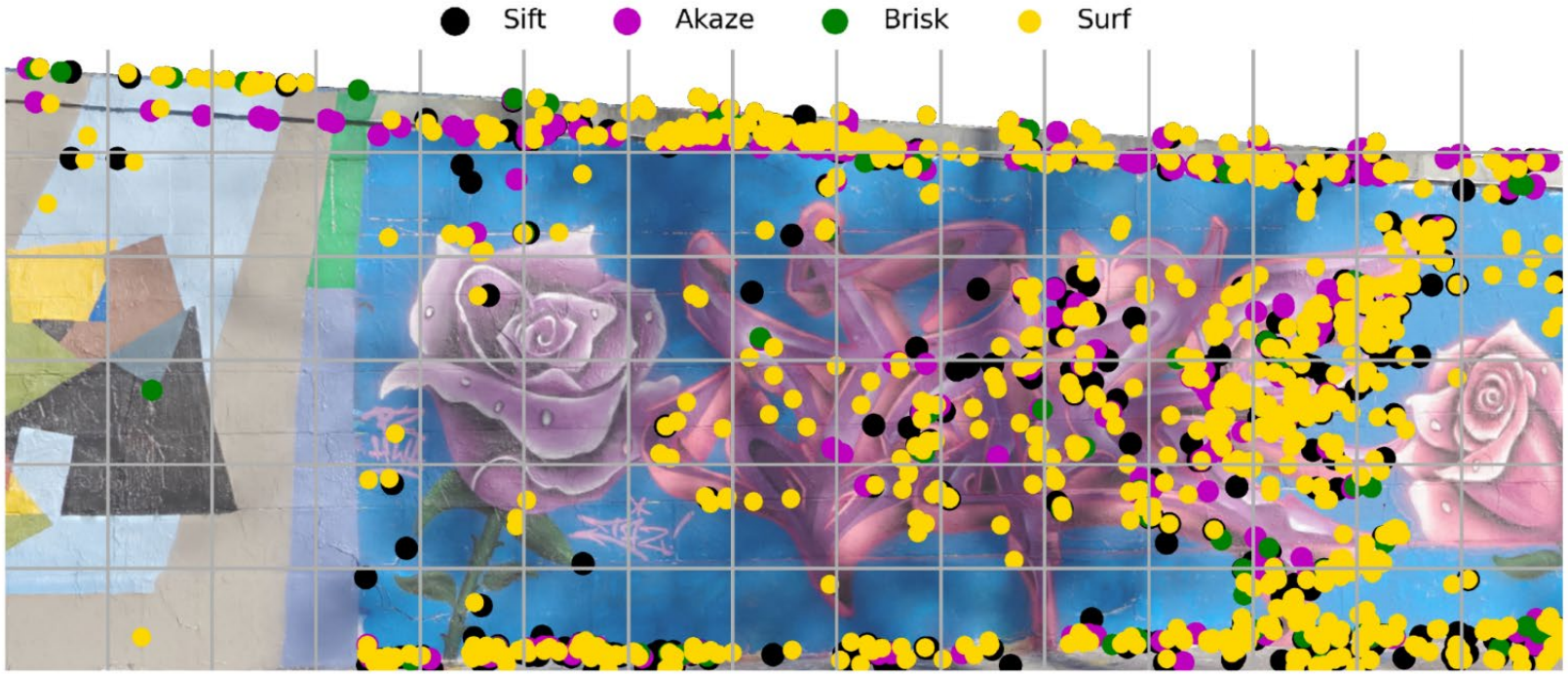
Descriptor-Based



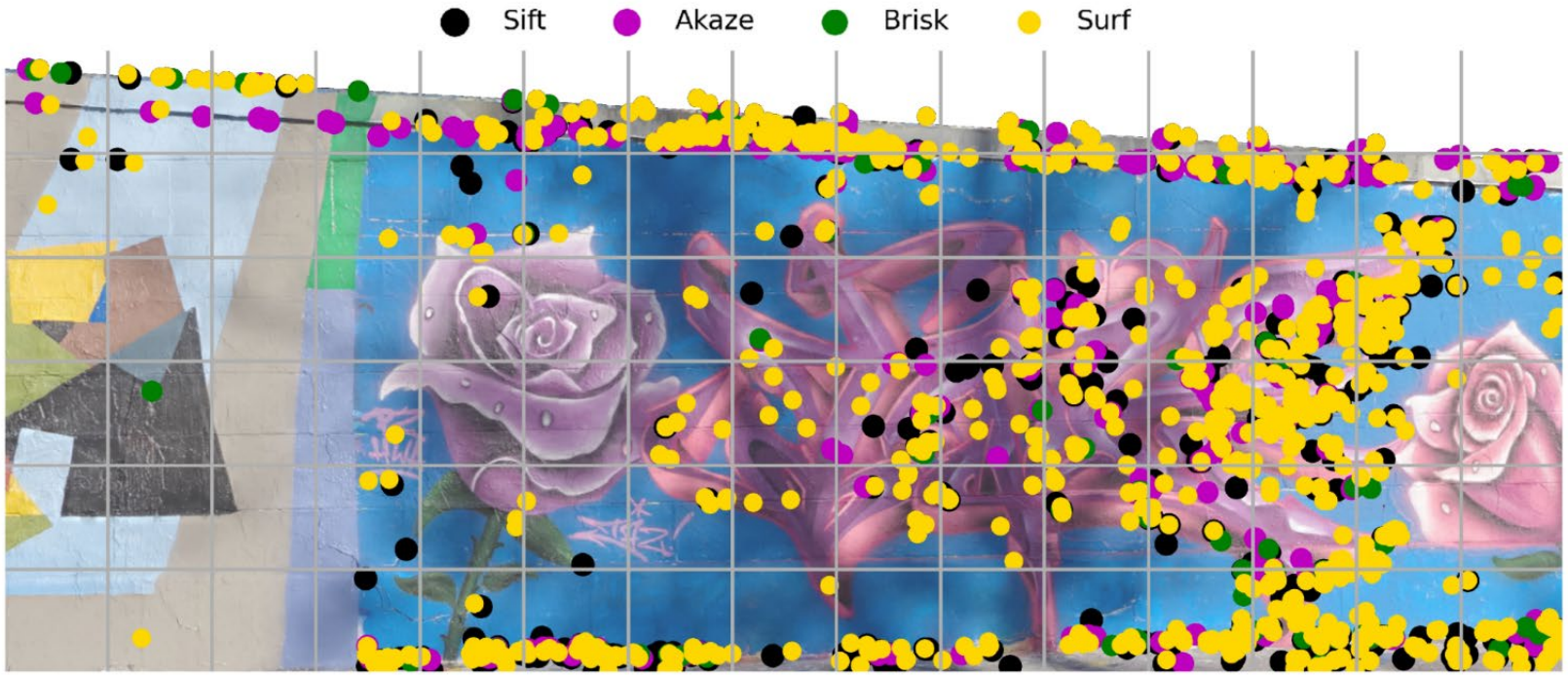


Descriptor-Based

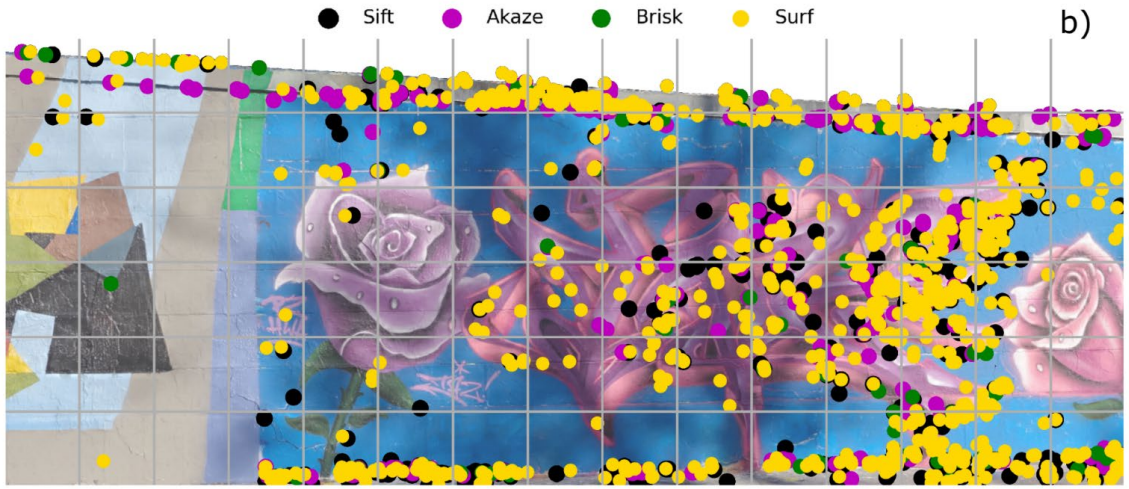
Descriptor-matching



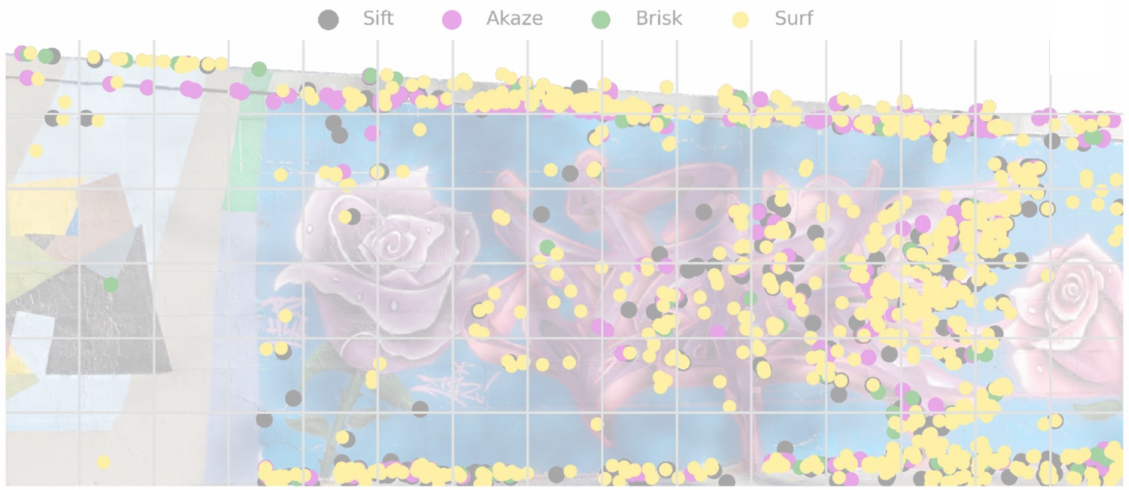
Descriptor-Based

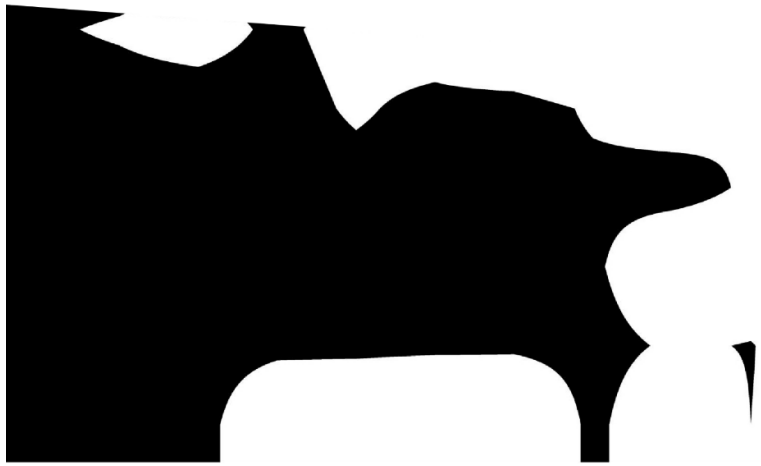


Descriptor-Based

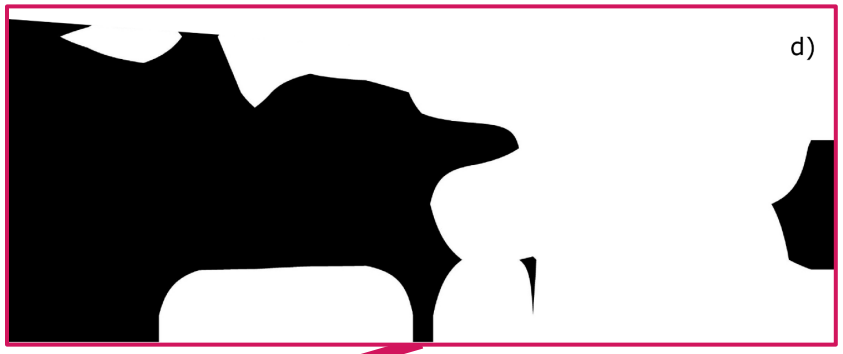


Descriptor-Based



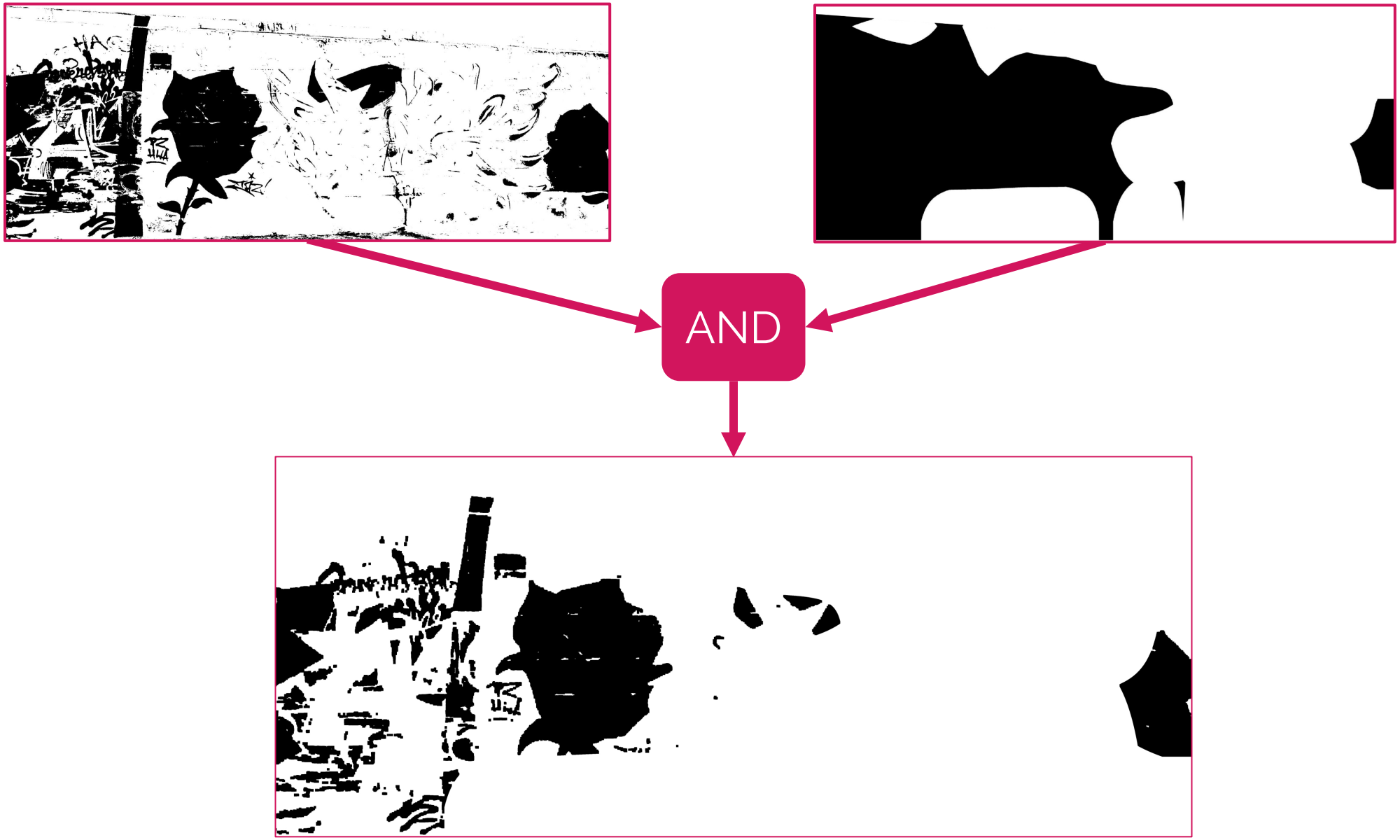


Hybrid change detection

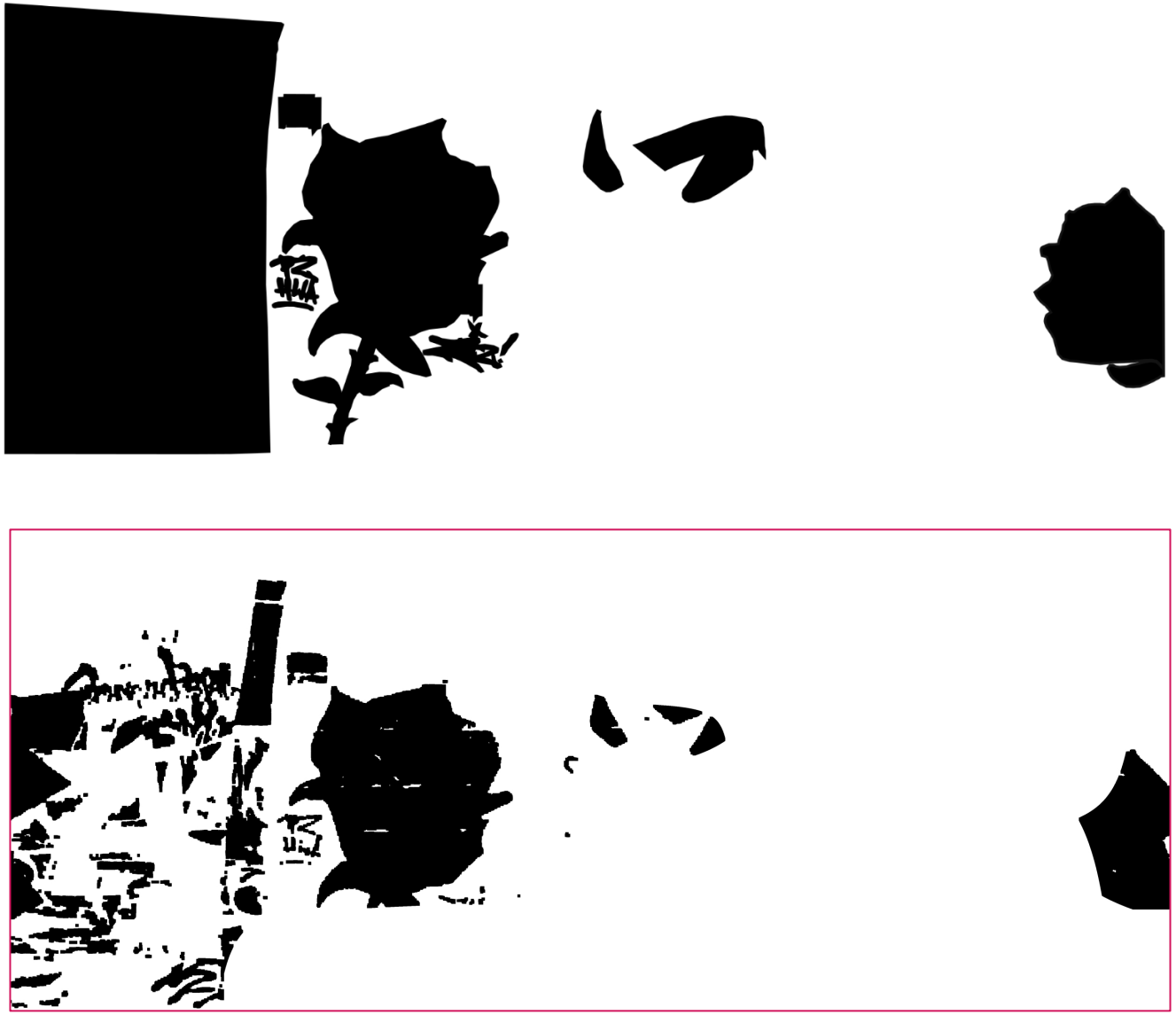


AND

Hybrid change detection



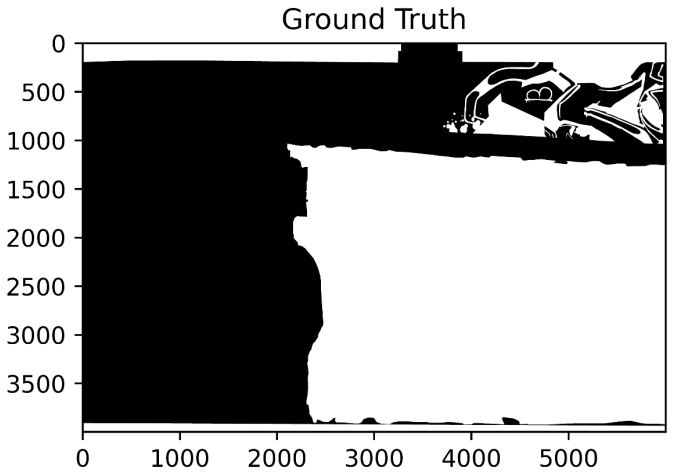
Hybrid change detection

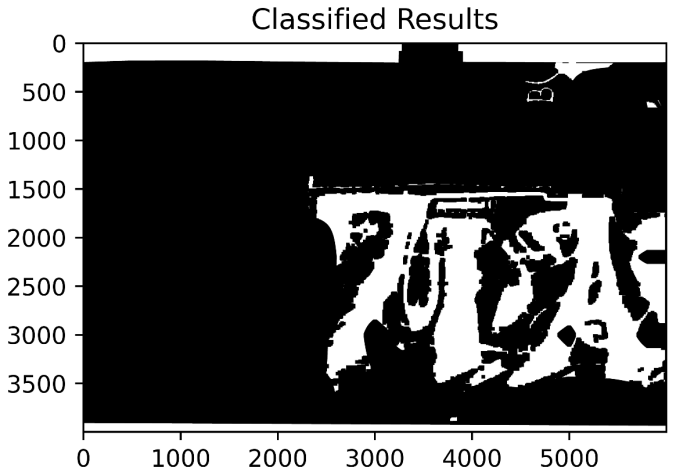


Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference
← „New“



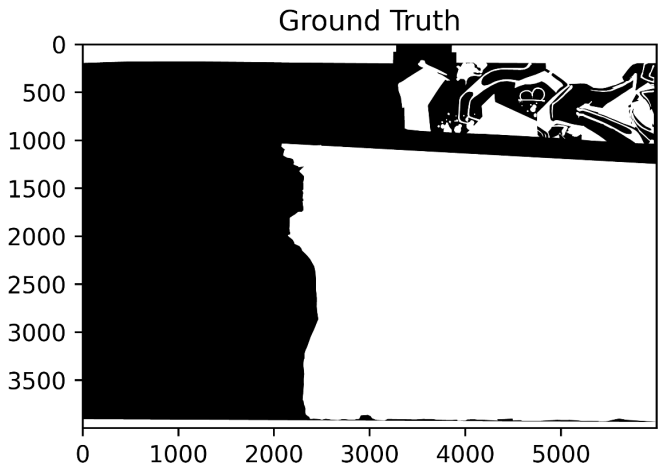


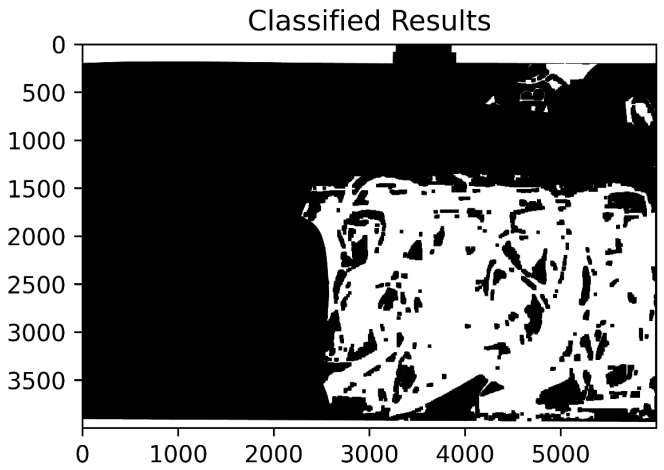
Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
	10-A
12.11.2022	10-B
	11
	10-A
13.11.2022	10-B
	11
	10-A
14.11.2022	10-B
	11
	10-A
17.11.2022	10-B
	11
	10-A
19.11.2022	10-B
	11
	10-A
22.11.2022	10-B
	11
	10-A
25.11.2022	10-B
	11
	10-A
27.11.2022	10-B
	11
	10-A
01.12.2022	10-B
	11

← Reference

← „New“





Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
	10-A
13.11.2022	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

Reference

„New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
	10-A
12.11.2022	10-B
	11
	10-A
13.11.2022	10-B
	11
	10-A
14.11.2022	10-B
	11
	10-A
17.11.2022	10-B
	11
	10-A
19.11.2022	10-B
	11
	10-A
22.11.2022	10-B
	11
	10-A
25.11.2022	10-B
	11
	10-A
27.11.2022	10-B
	11
	10-A
01.12.2022	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
	10-A
12.11.2022	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

← „New“

6902 combinations

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
	10-A
13.11.2022	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

Reference

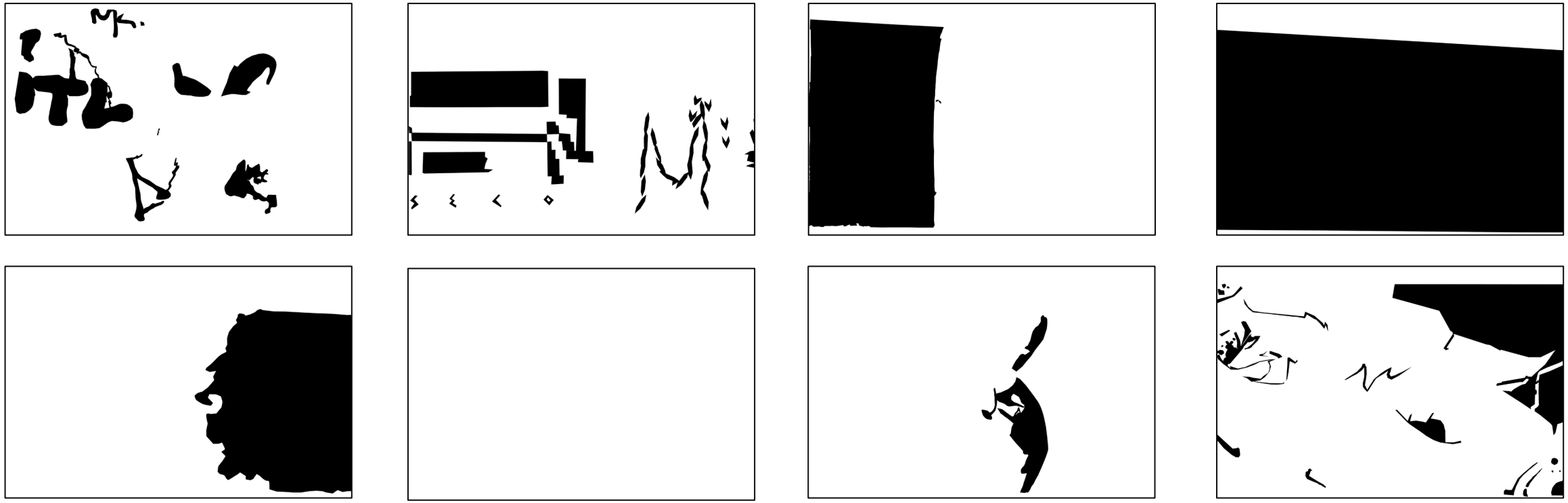
„New“

„New“

6902 combinations

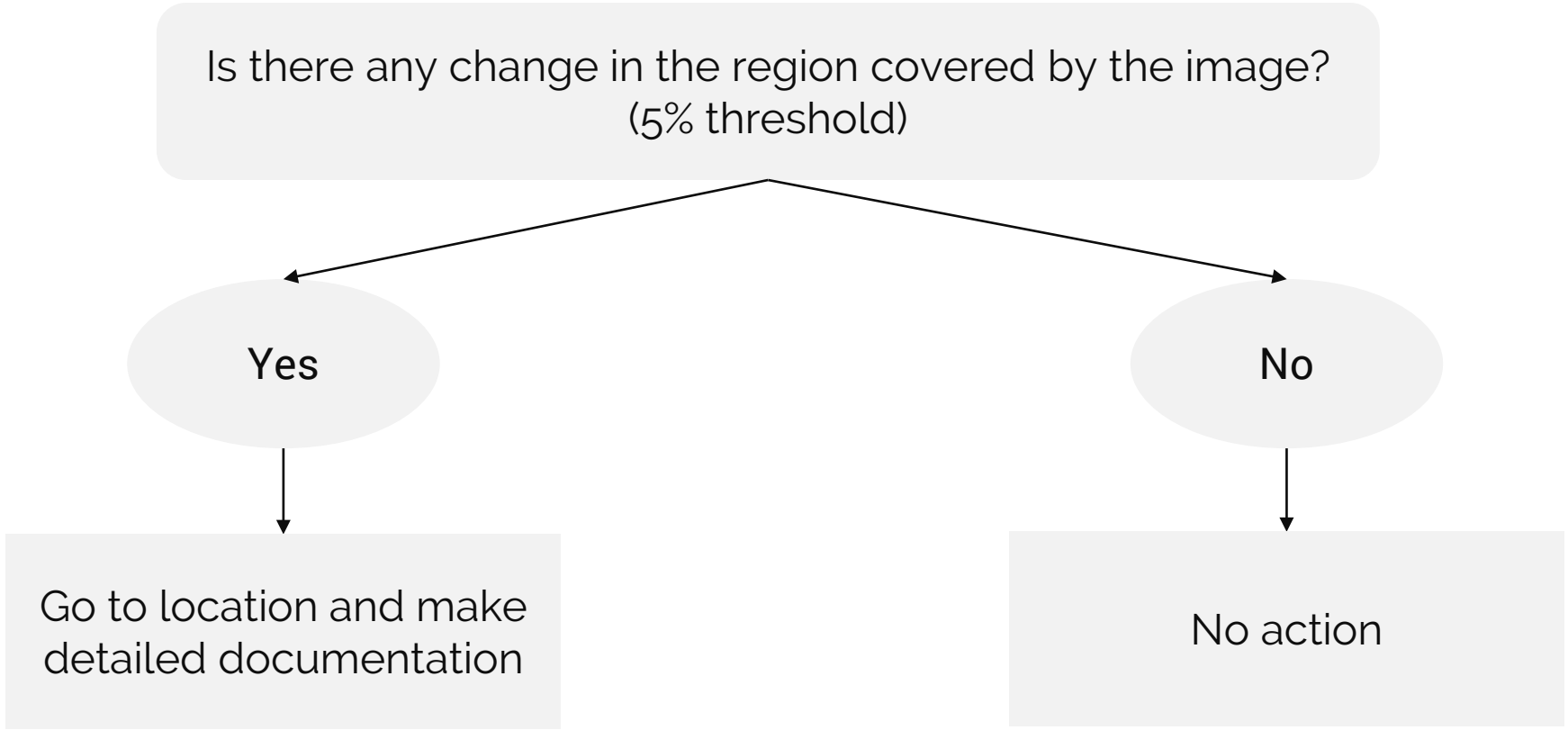
Reference dataset

6902 reference change maps



Experiment 1

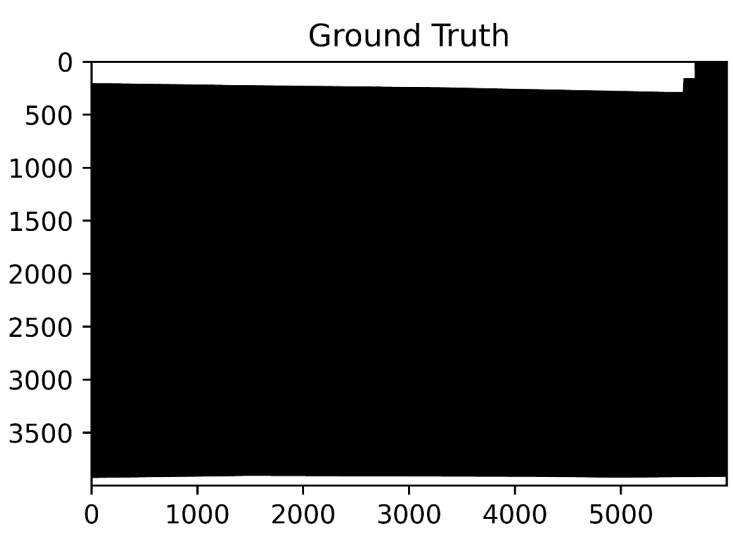
Binary classification of **whole images**

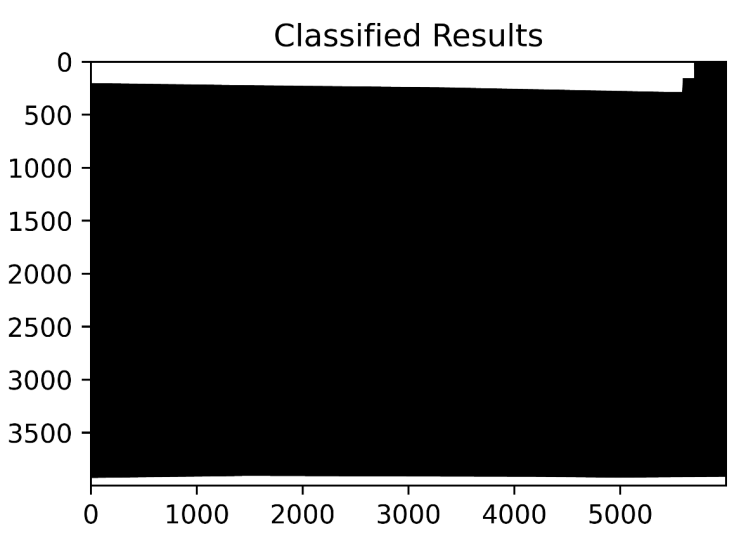


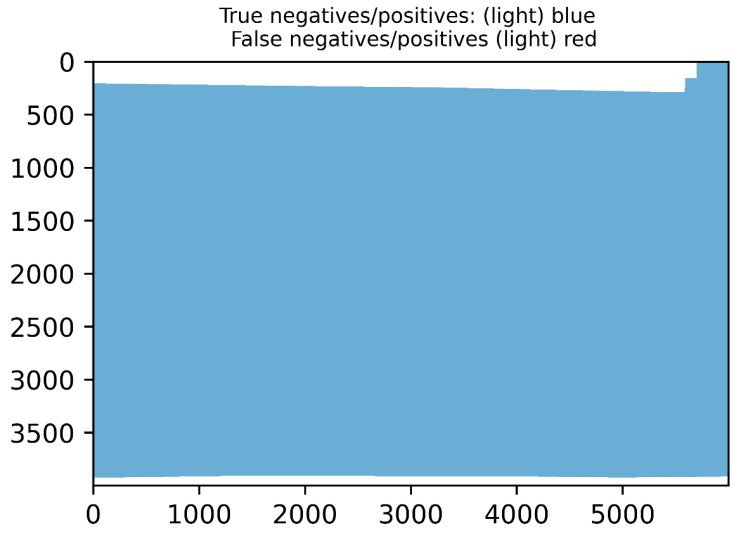
5930 of 6902 → 86% correct

Experiment 2

Pixel based metrics

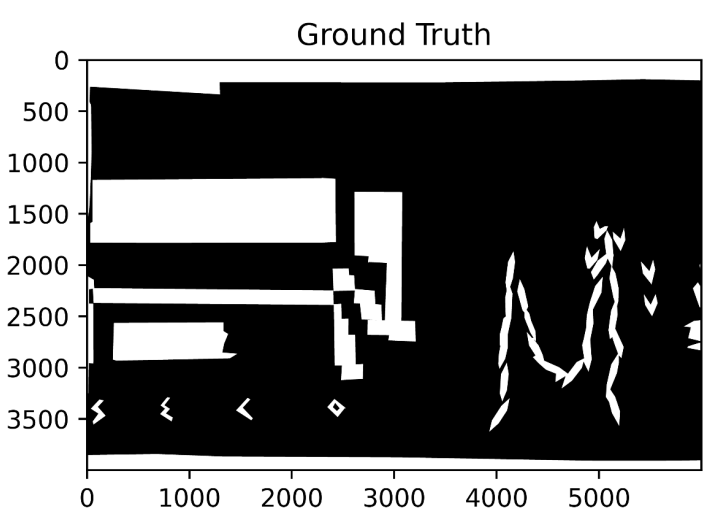


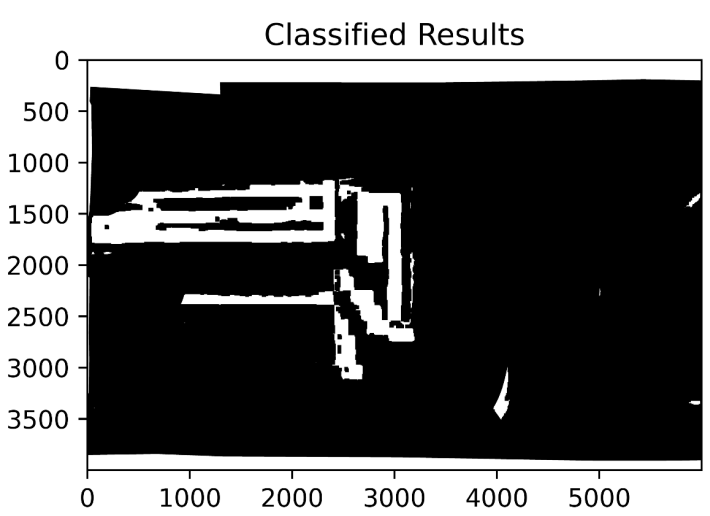


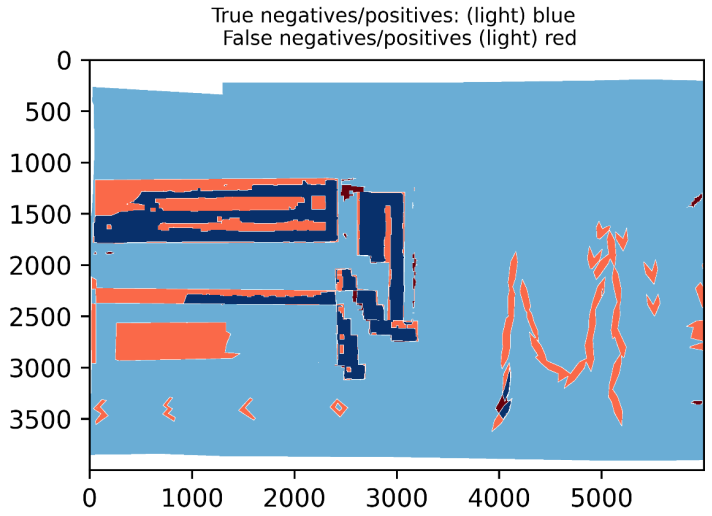


Experiment 2

Pixel based metrics





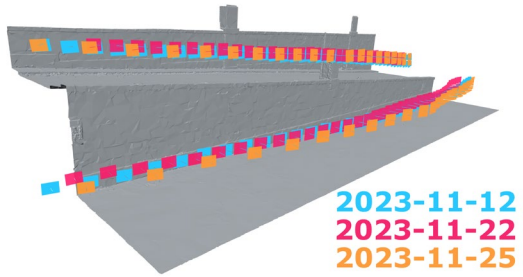


Conclusions

- Fast image acquisition

Conclusions

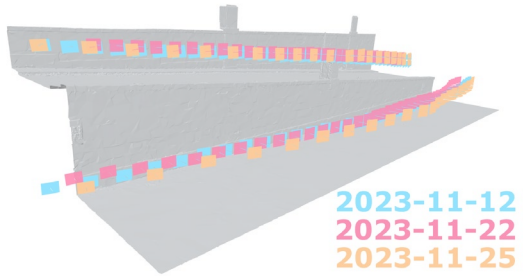
- Fast image acquisition
- **Efficient co-registration**



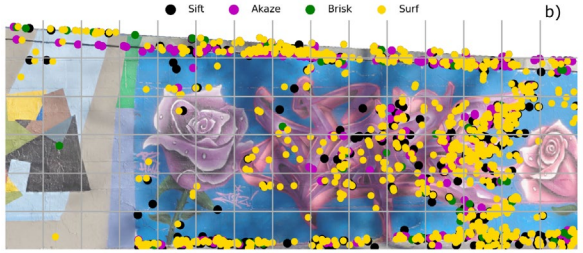
Conclusions

- Fast image acquisition

- Efficient co-registration

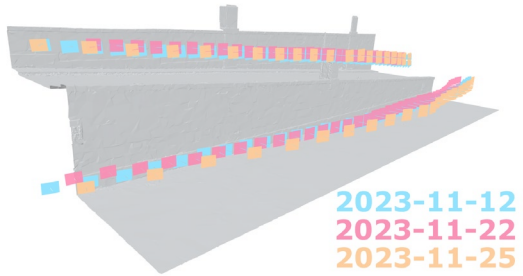


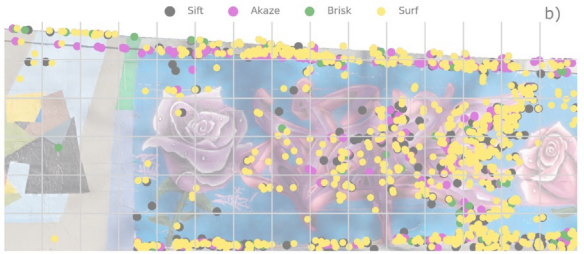
- **Robust hybrid change detection (shadows)**

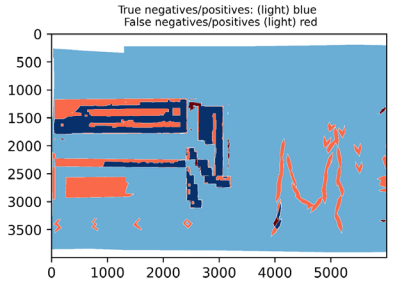


Conclusions

- Fast image acquisition
- Efficient co-registration
- Robust hybrid change detection (shadows)
- **Not yet sensitive enough to small changes**







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