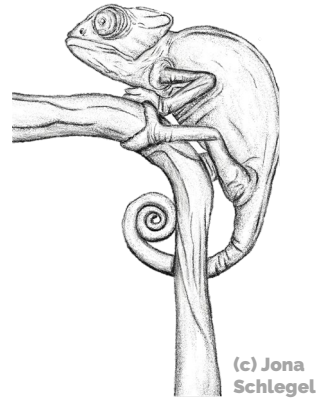




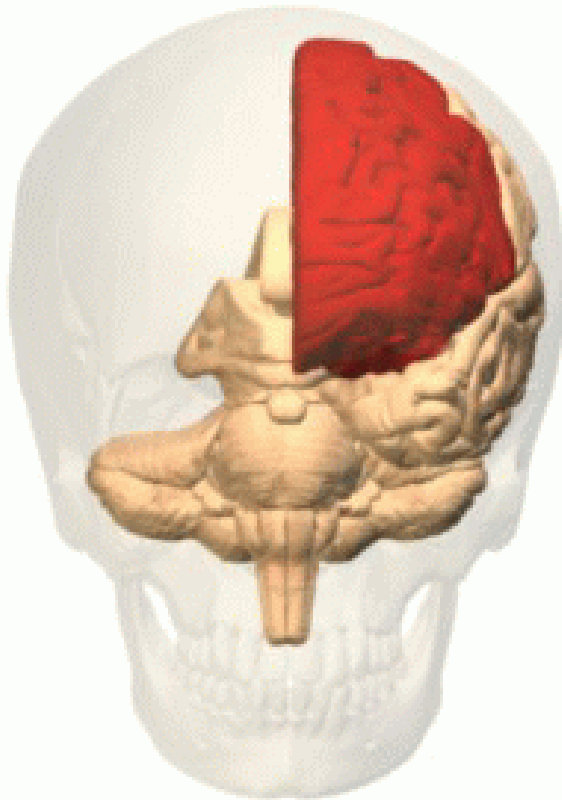
Towards an automated detection of changes in the urban chameleon skin

Benjamin Wild, Geert Verhoeven, and Norbert Pfeifer

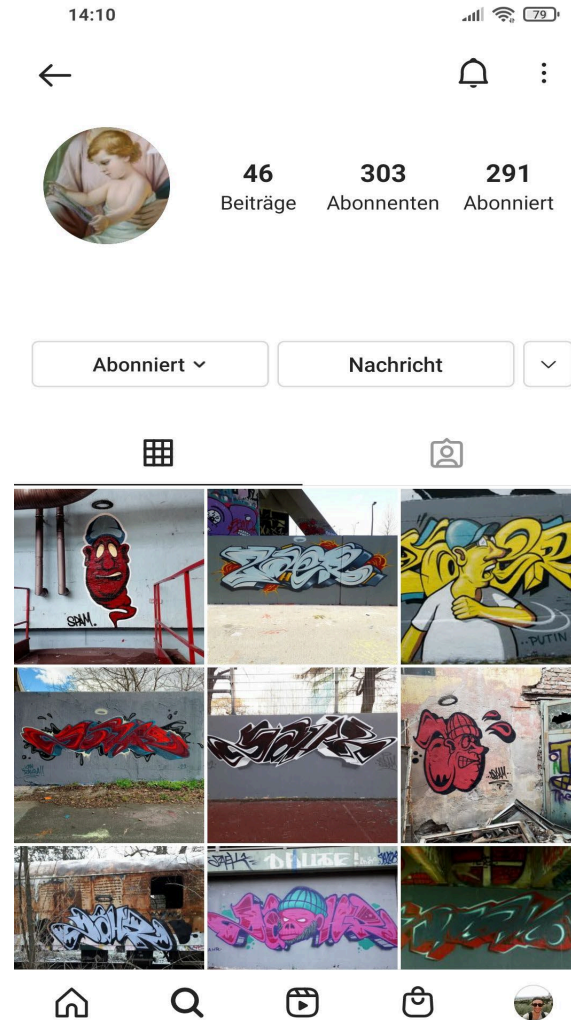
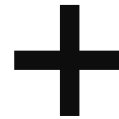




Monitoring so far



Life Science Databases (CC-BY-SA)



#INDIGODonaukanal

Automated change detection

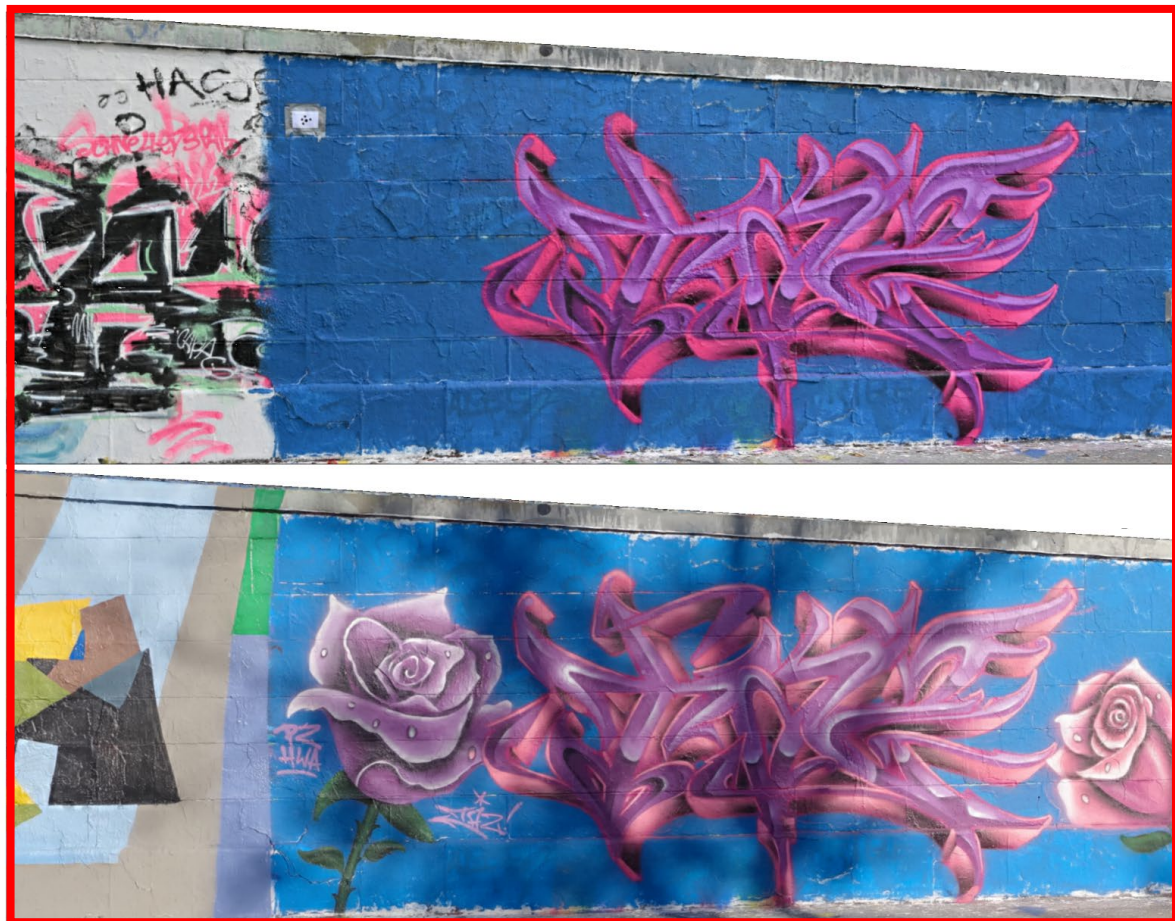
Aim



Aim



Challenge 1



Aim

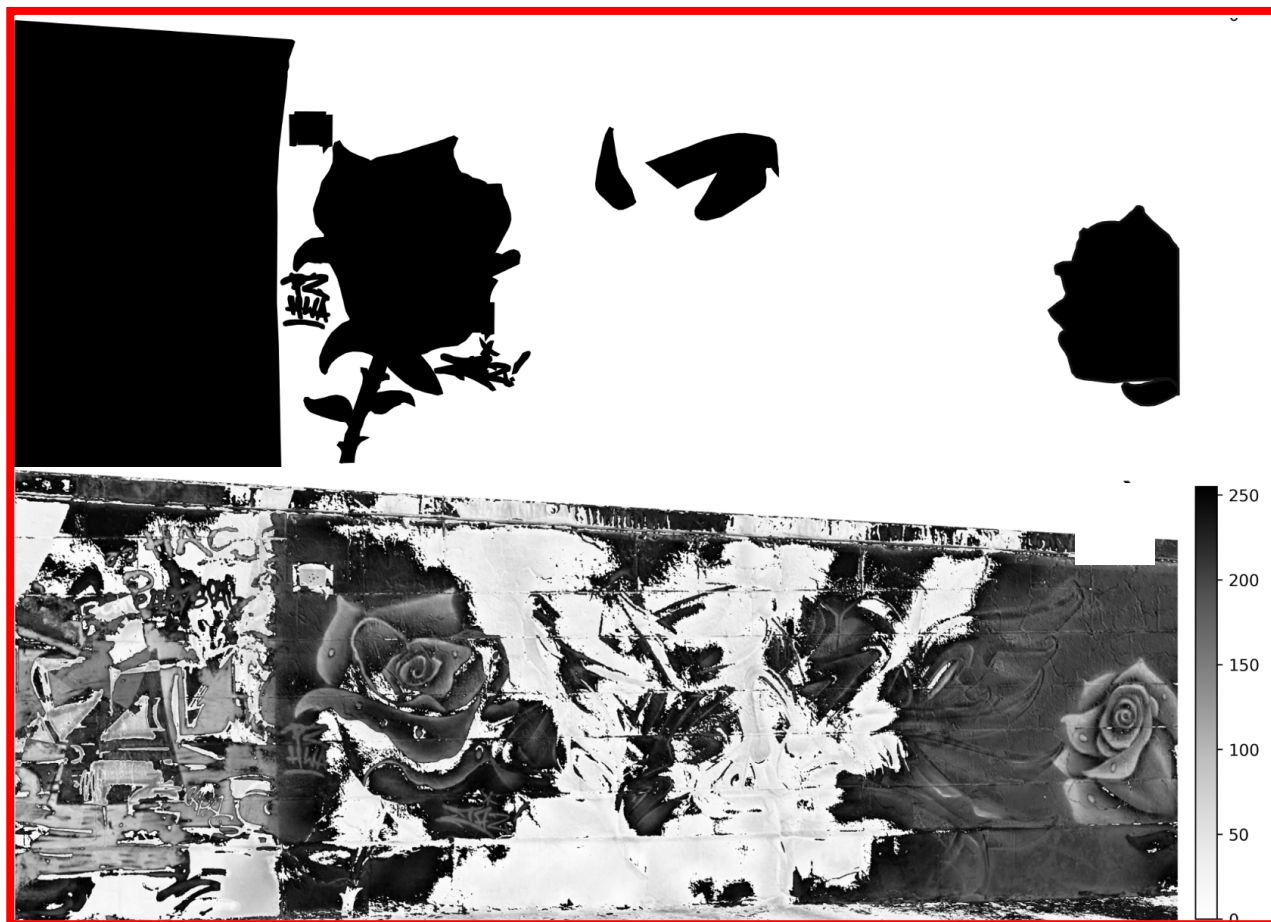


Challenge 1



Aim

Challenge 2



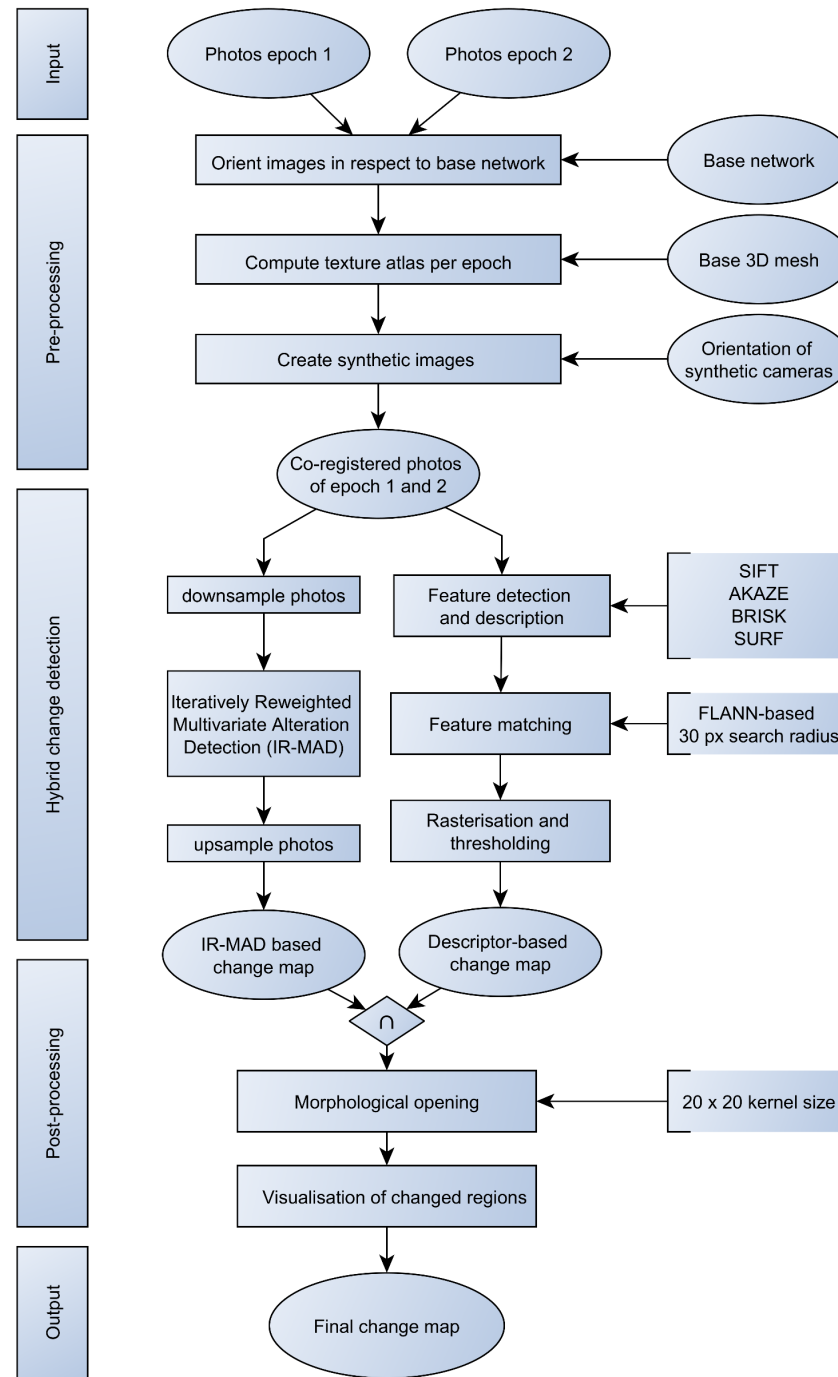


Image acquisition

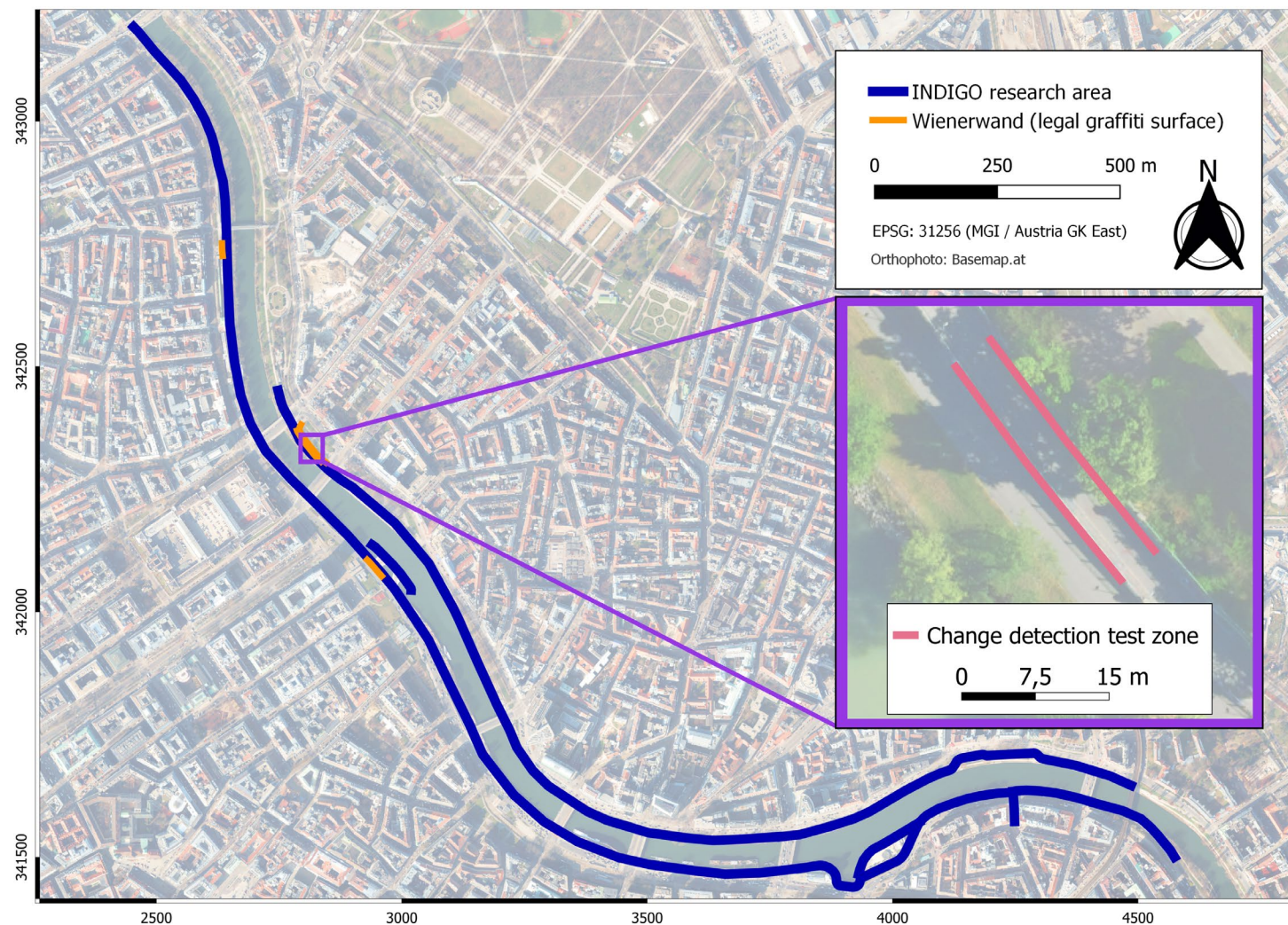


Image acquisition



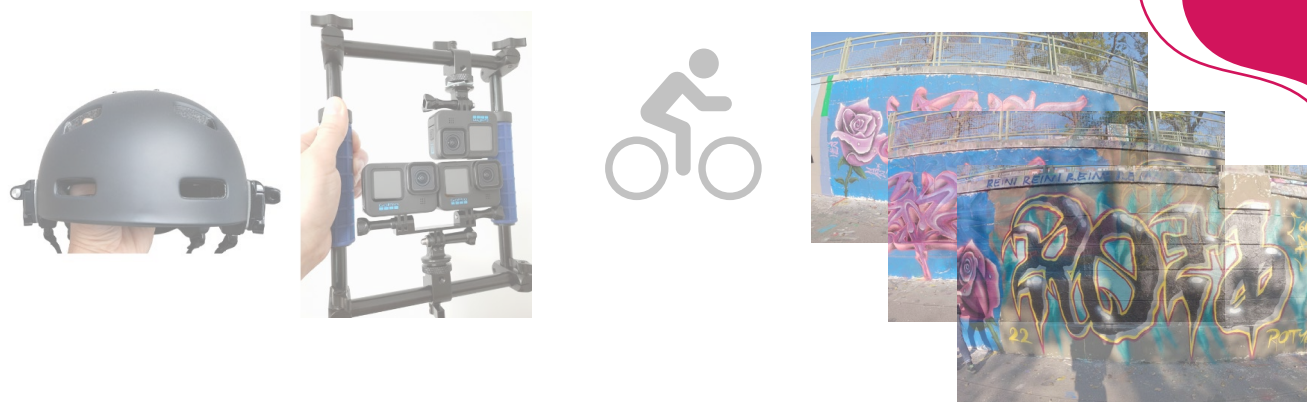
Image acquisition

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



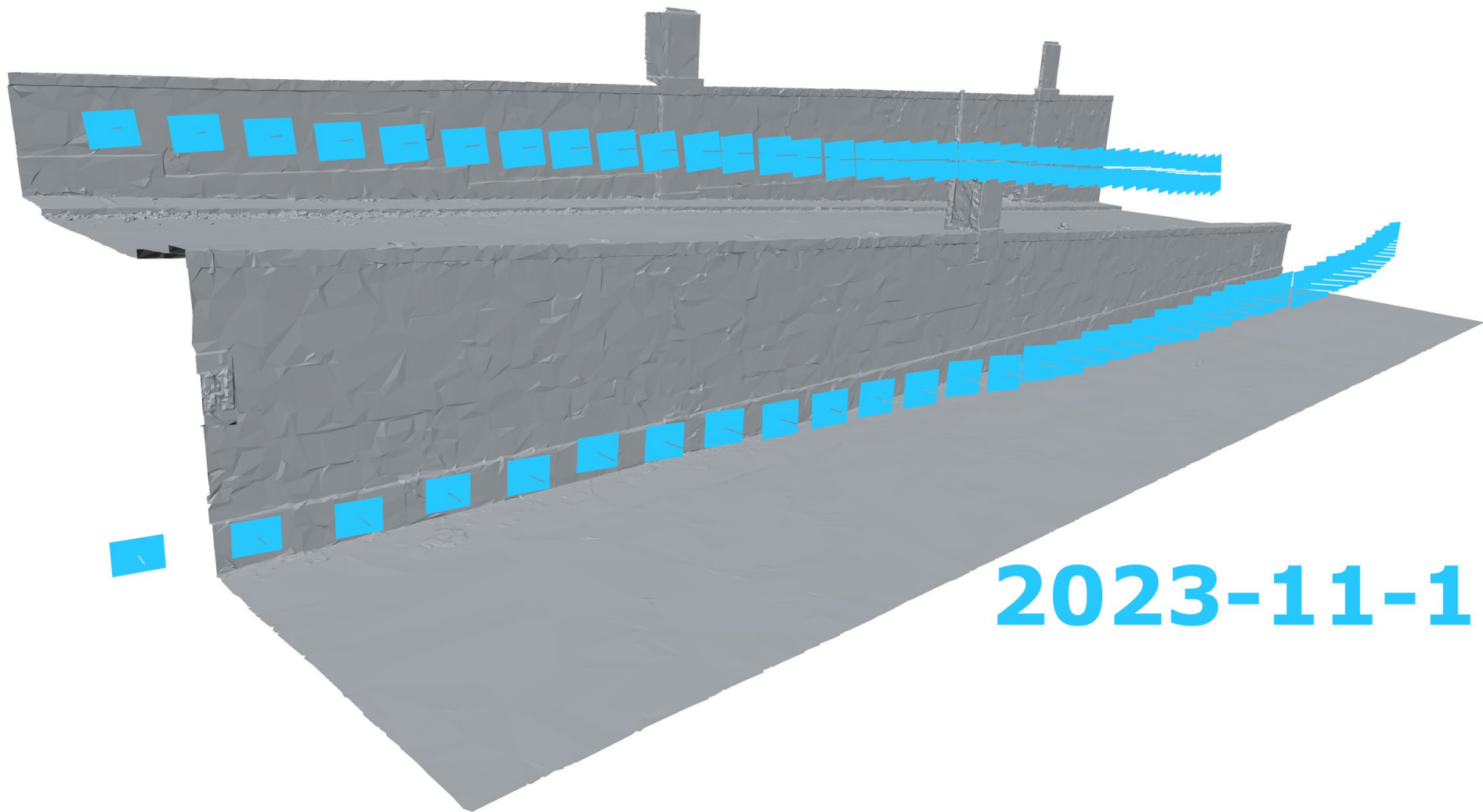
Structure from Motion



Photo A

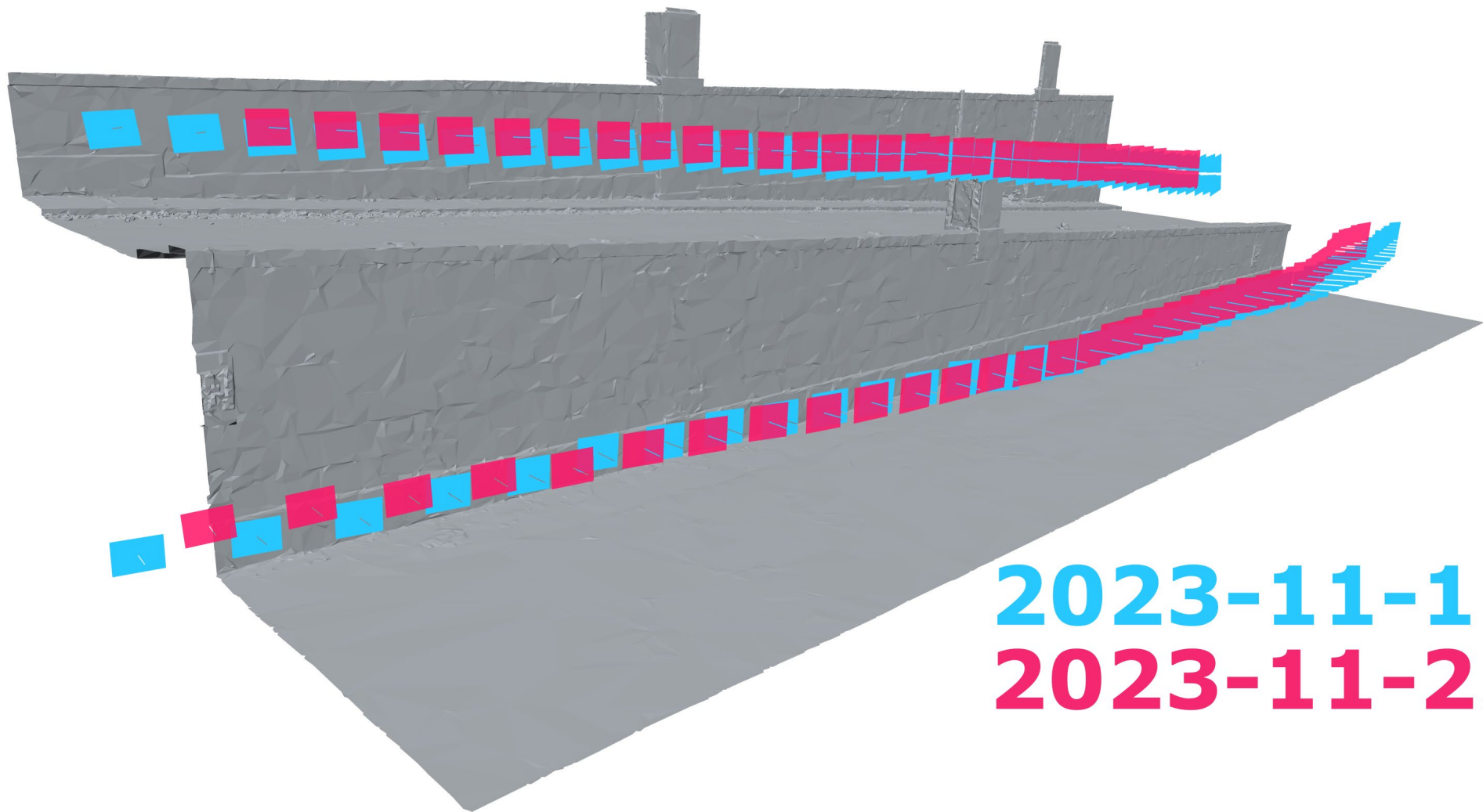
Photo B

Co-registration



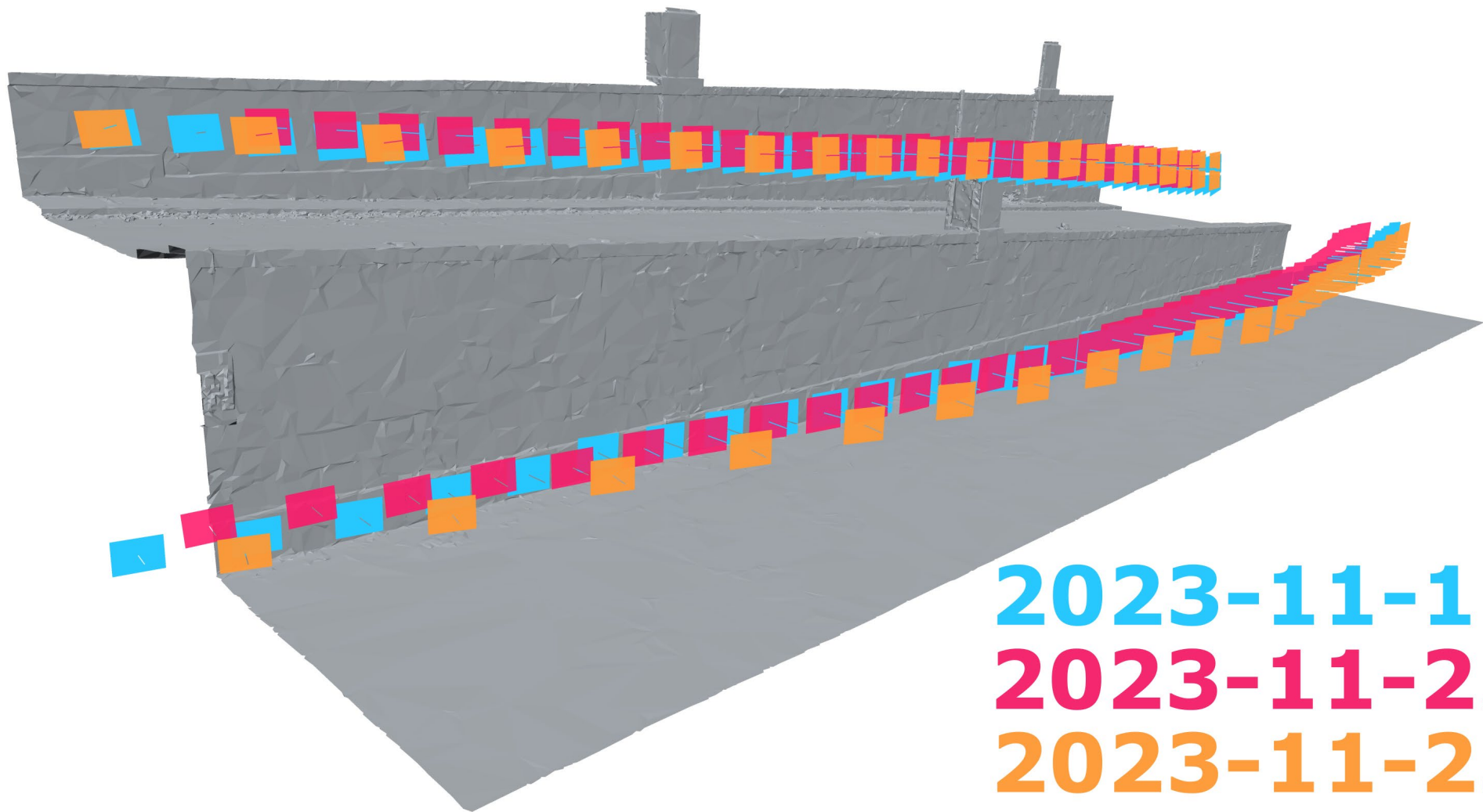
2023-11-12

Co-registration

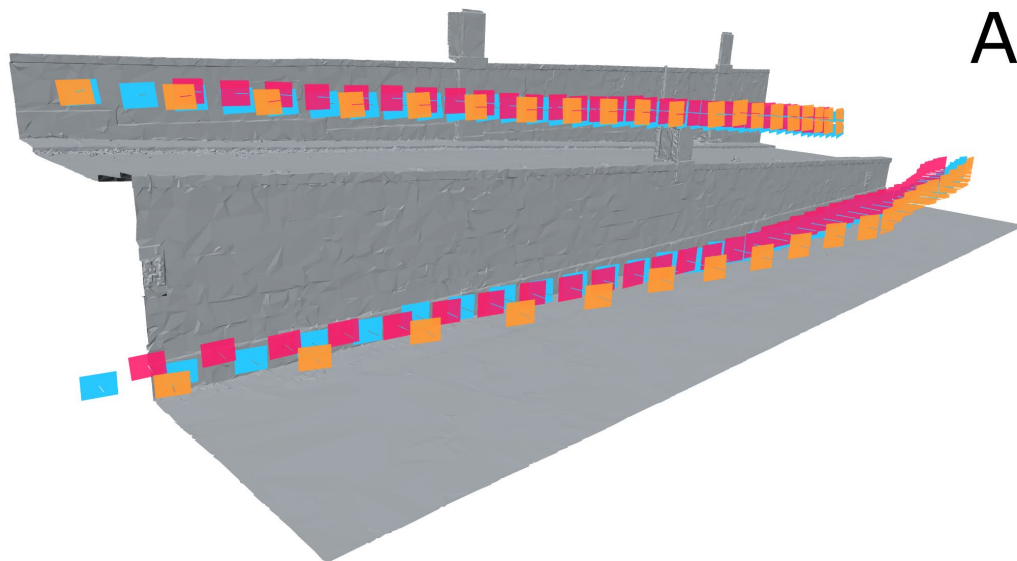


2023-11-12
2023-11-22

Co-registration

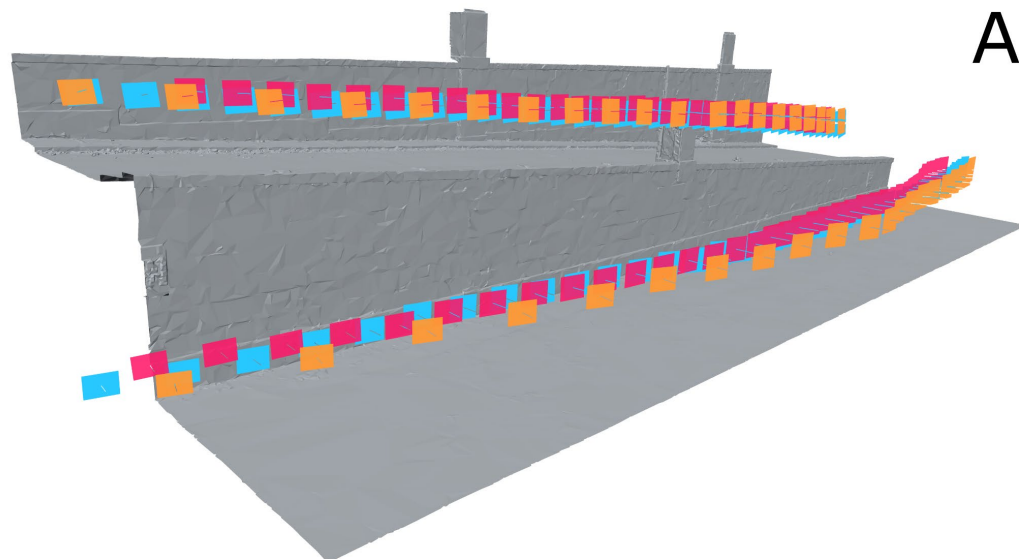


Co-registration



A

Co-registration



2023-11-12



2023-11-22



2023-11-25

Co-registration



2022-10-21_Z7ii-A

Co-registration



Co-registration











2022-10-21_Z7ii-A



Result from one synthetic cameras

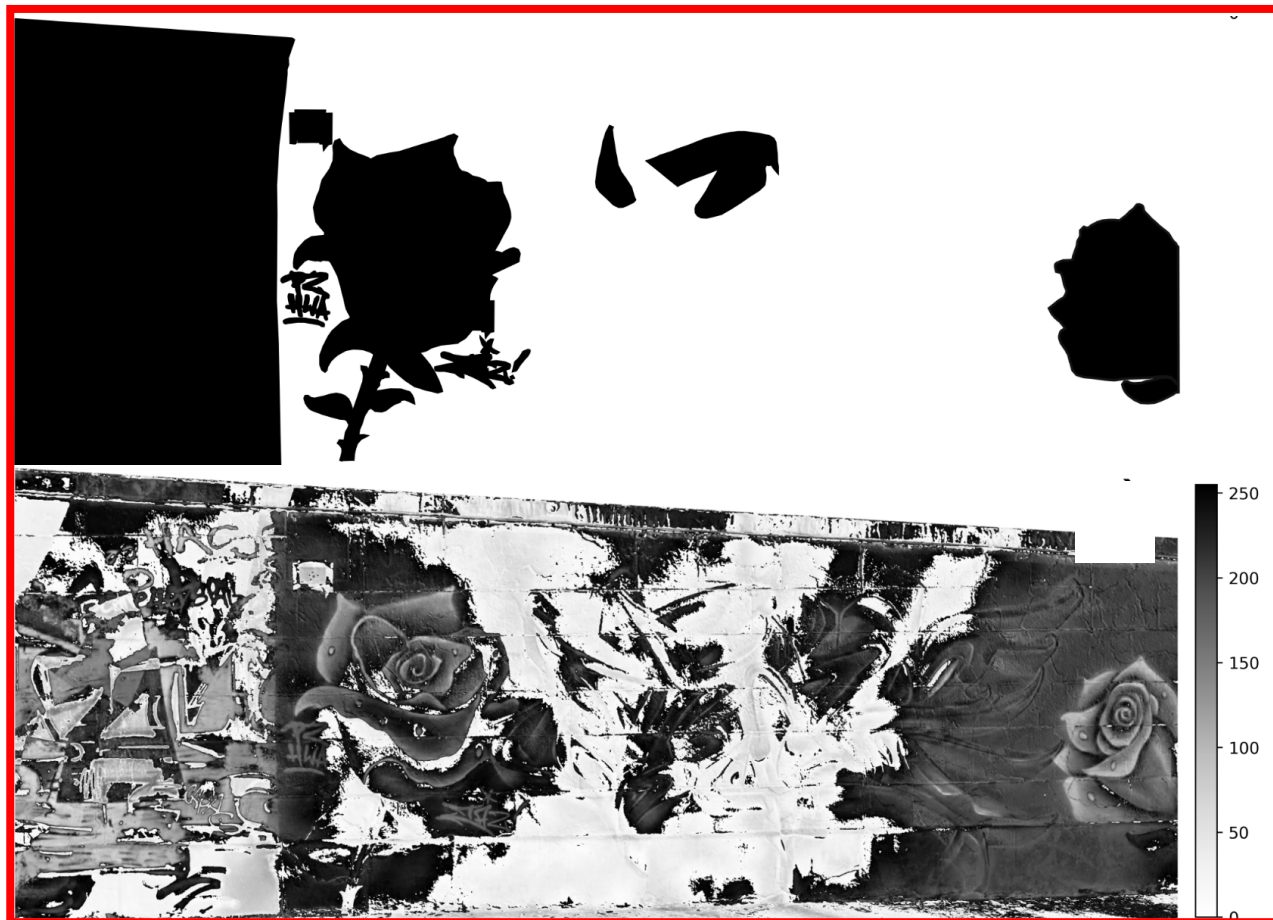
$$\begin{array}{ccccc}
 17 & \times & 29 & = & 493 \\
 \text{Synthetic cameras} & & \text{Acquisitions} & & \text{Synthetic Images}
 \end{array}$$

Challenge 1

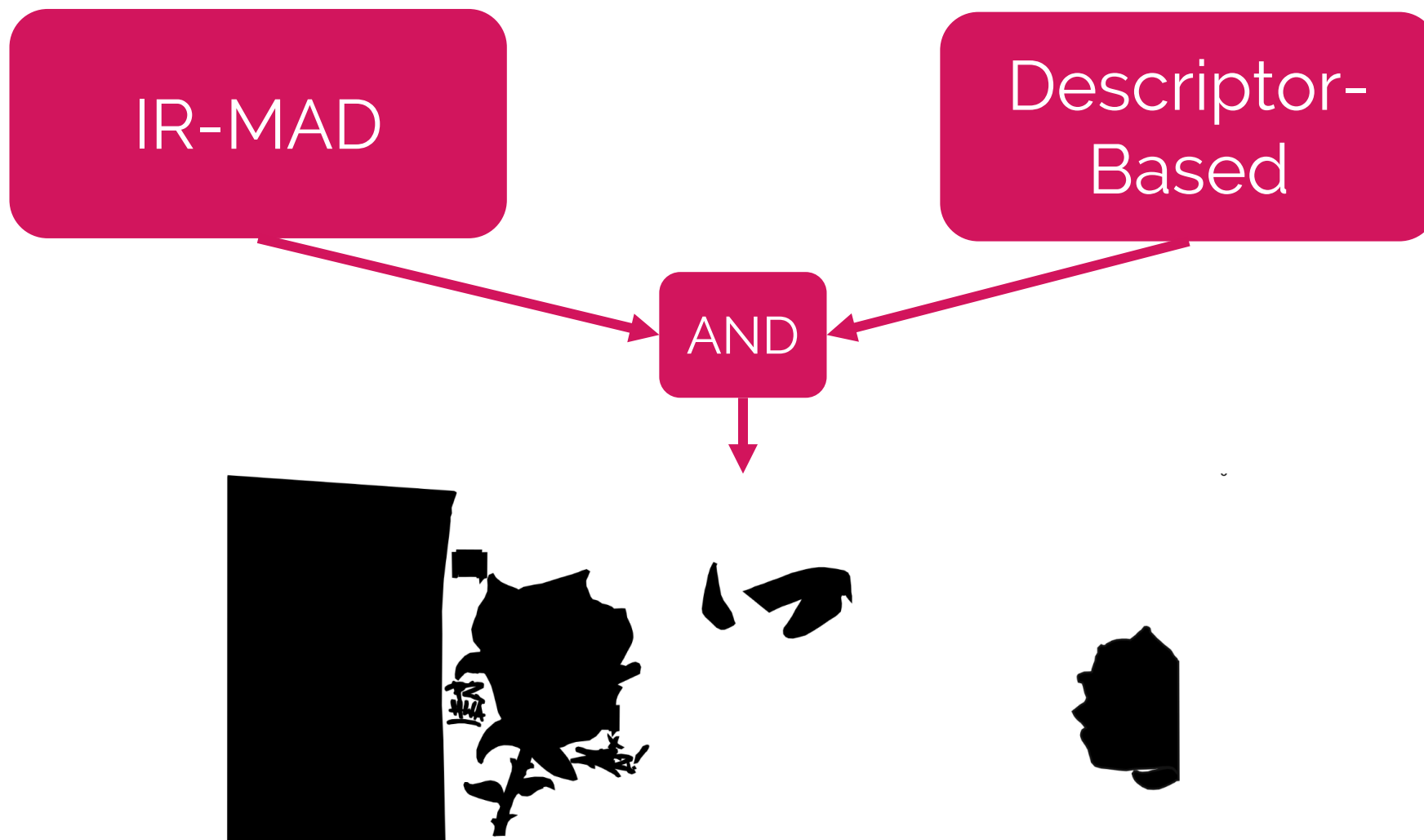


Aim

Challenge 2



Hybrid change detection



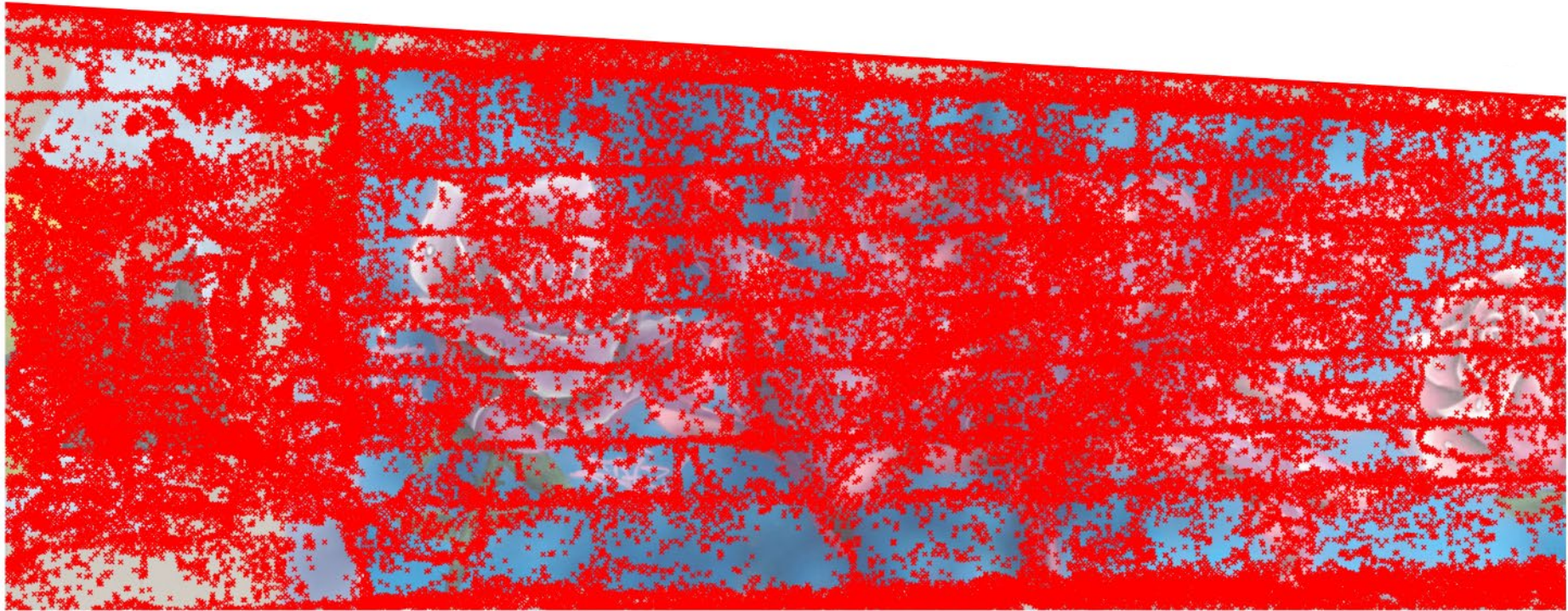
Iteratively Reweighted Multivariate Alteration Detection (IRMAD; Nielsen 2007)

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

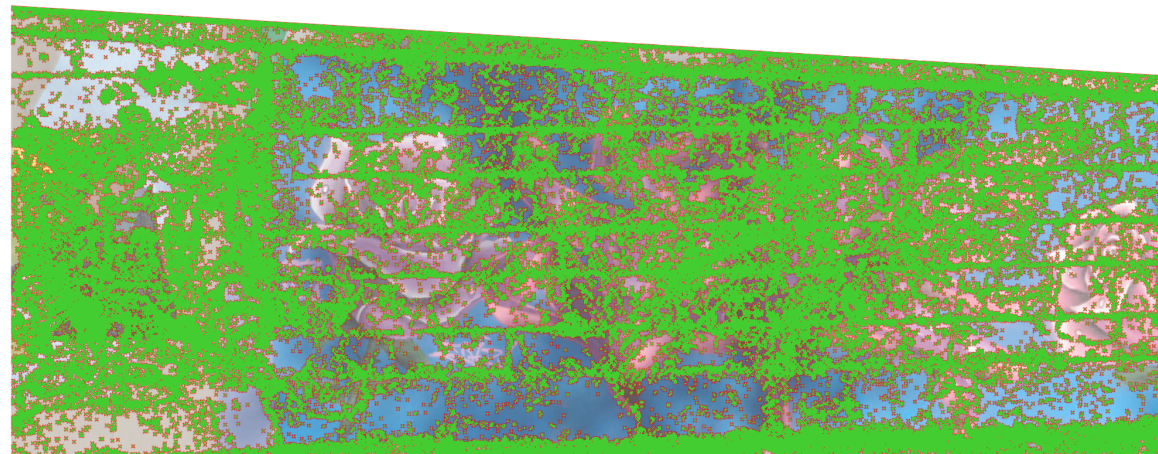
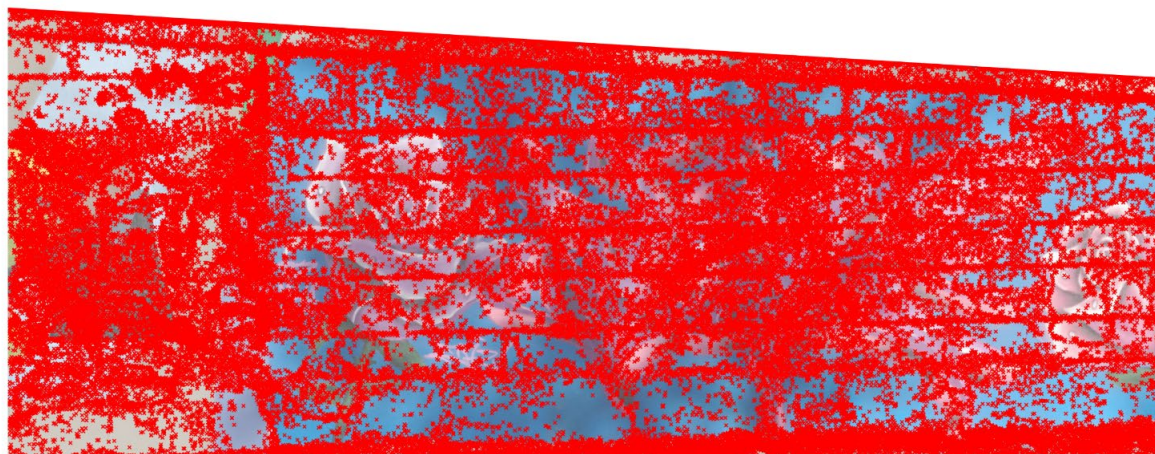


Descriptor-Based

Descriptor = Fingerprint of a pixel

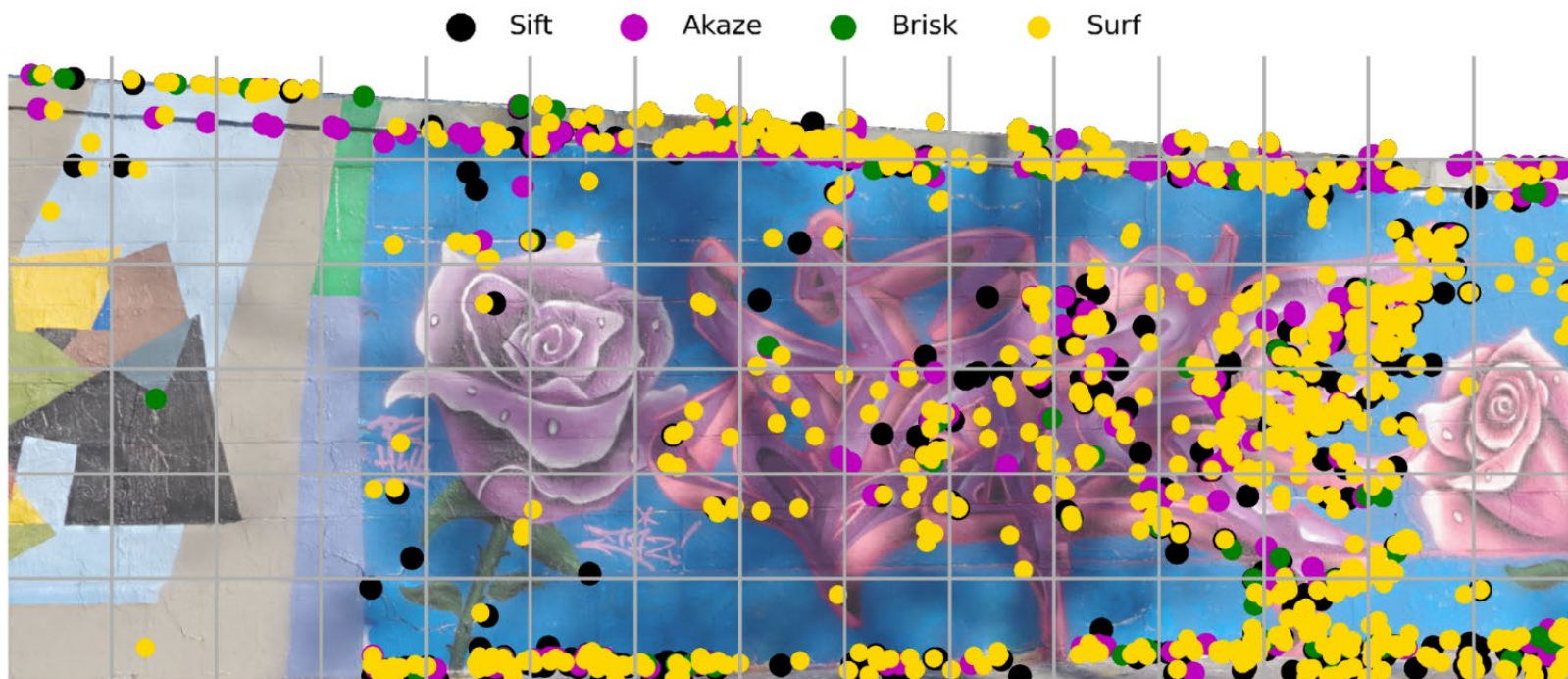


Descriptor-Based

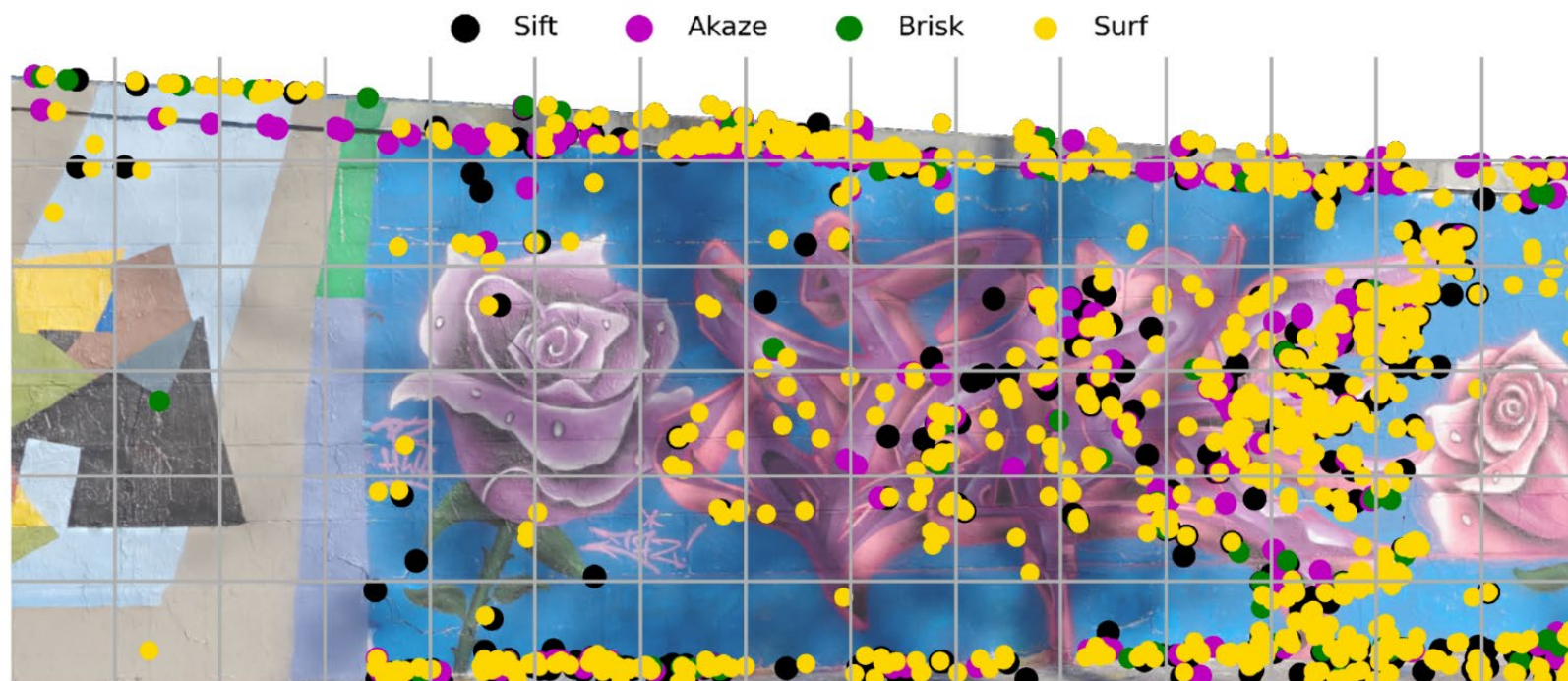


Descriptor-Based

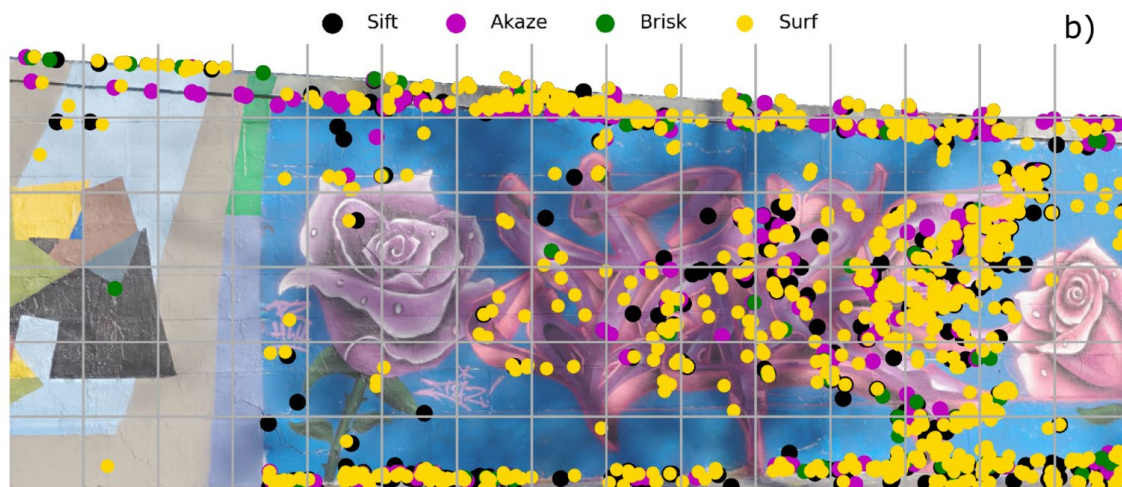
Descriptor-matching



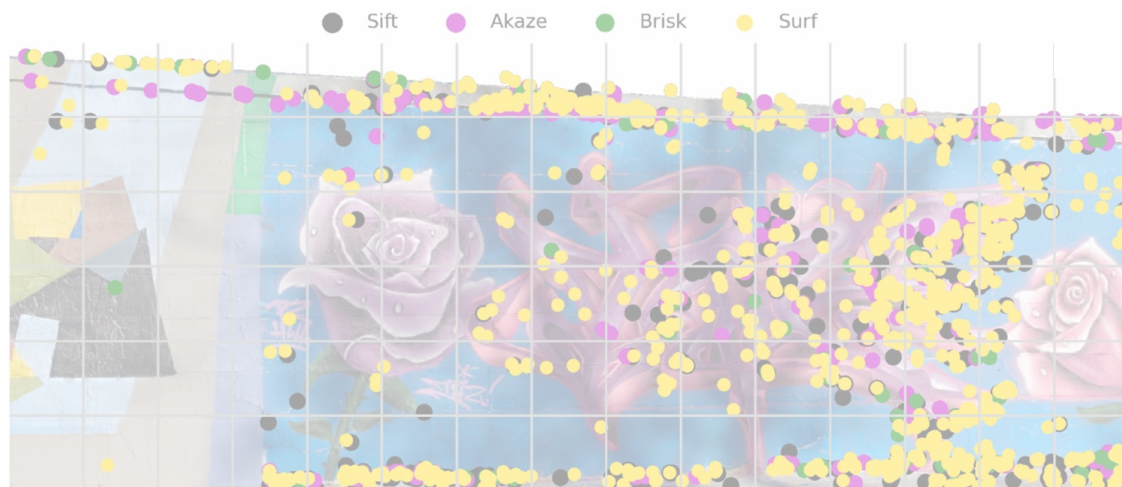
Descriptor-Based



Descriptor-Based



Descriptor-Based



Hybrid change detection



AND

Hybrid change detection



AND



Hybrid change detection

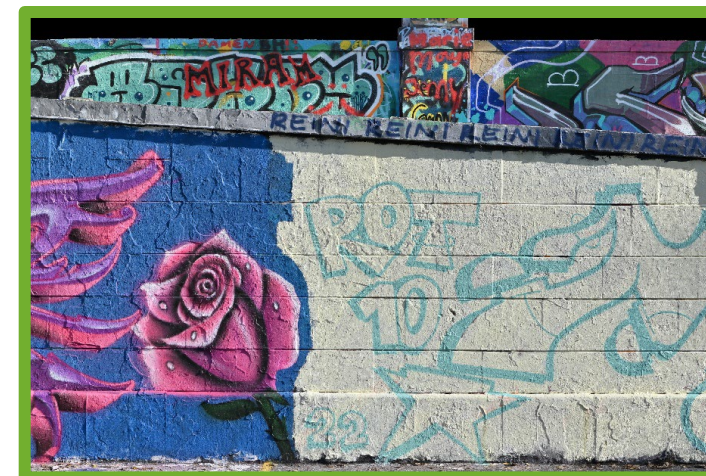


Experiment

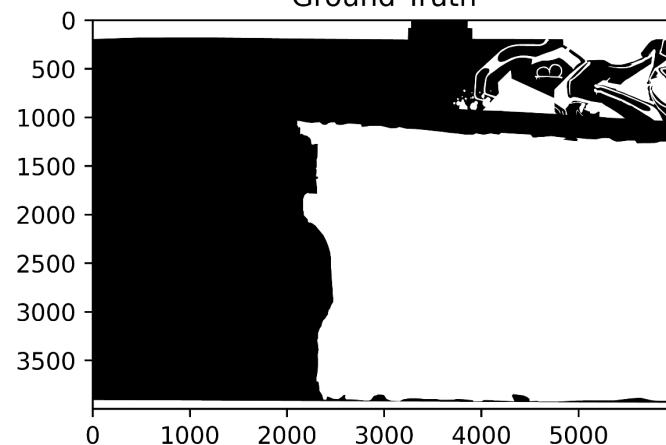
Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
12.11.2022	10-A
	10-B
	11
13.11.2022	10-A
	10-B
	11
14.11.2022	10-A
	10-B
	11
17.11.2022	10-A
	10-B
	11
19.11.2022	10-A
	10-B
	11
22.11.2022	10-A
	10-B
	11
25.11.2022	10-A
	10-B
	11
27.11.2022	10-A
	10-B
	11
01.12.2022	10-A
	10-B
	11

← Reference

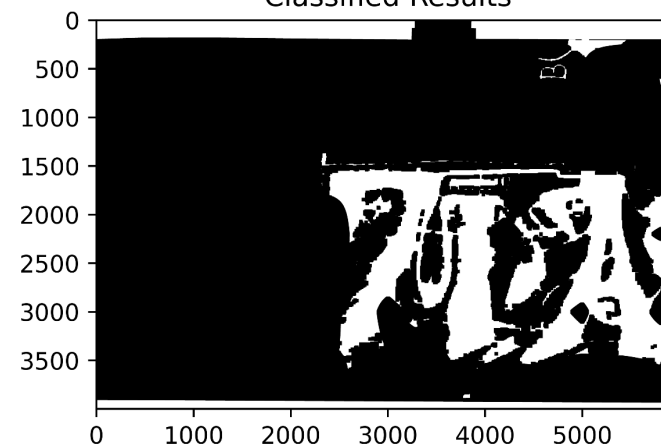
← „New“



Ground Truth



Classified Results

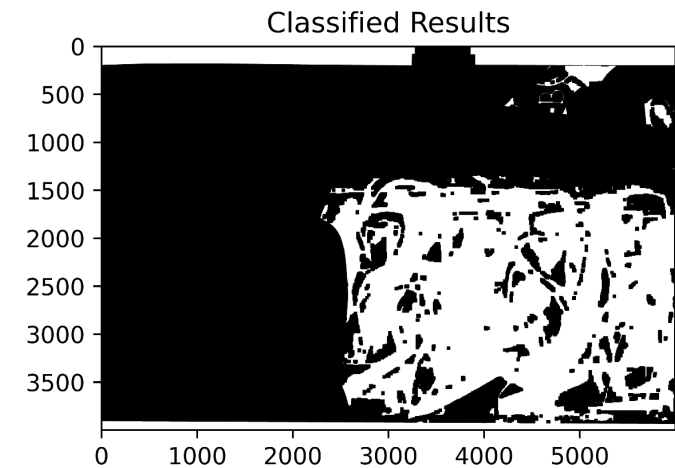
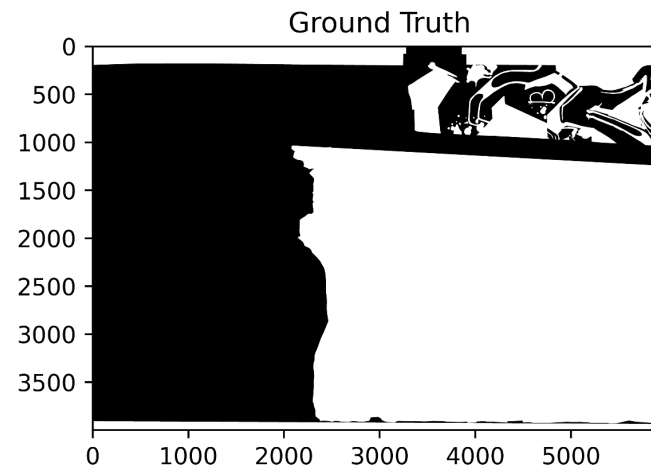


Experiment

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“



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
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“

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
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
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
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
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“

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“

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



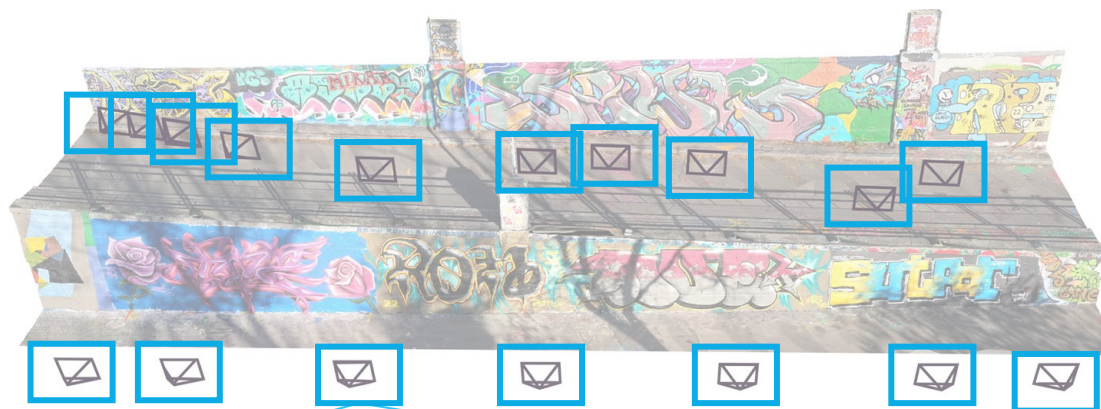
← „New“

Experiment

Day	Camera
21.10.2022	Z7ii
02.11.2022	Z7ii
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

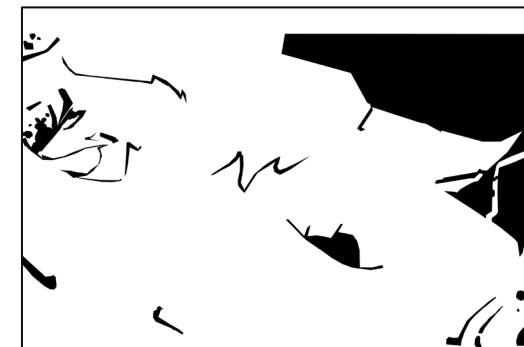
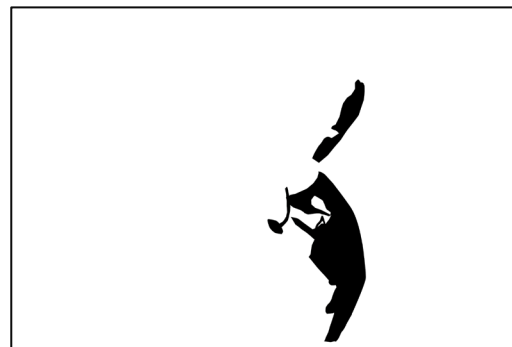
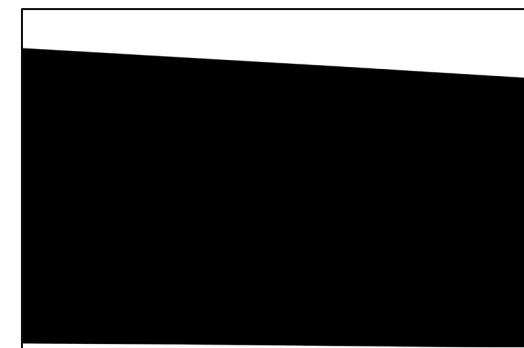
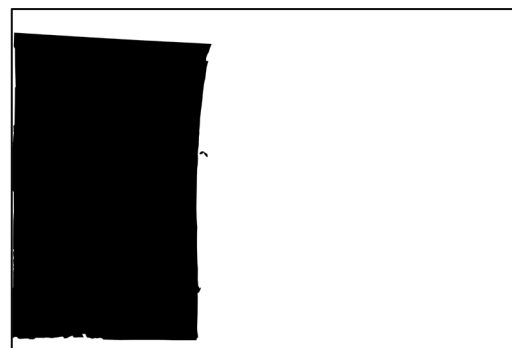
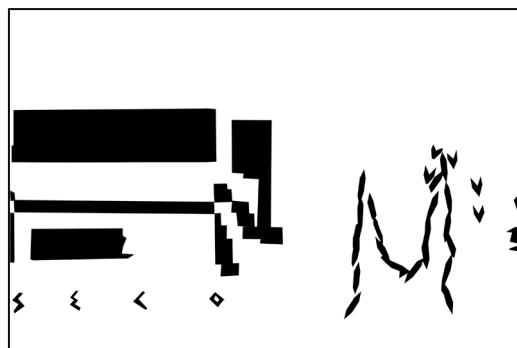
← „New“



6902 combinations

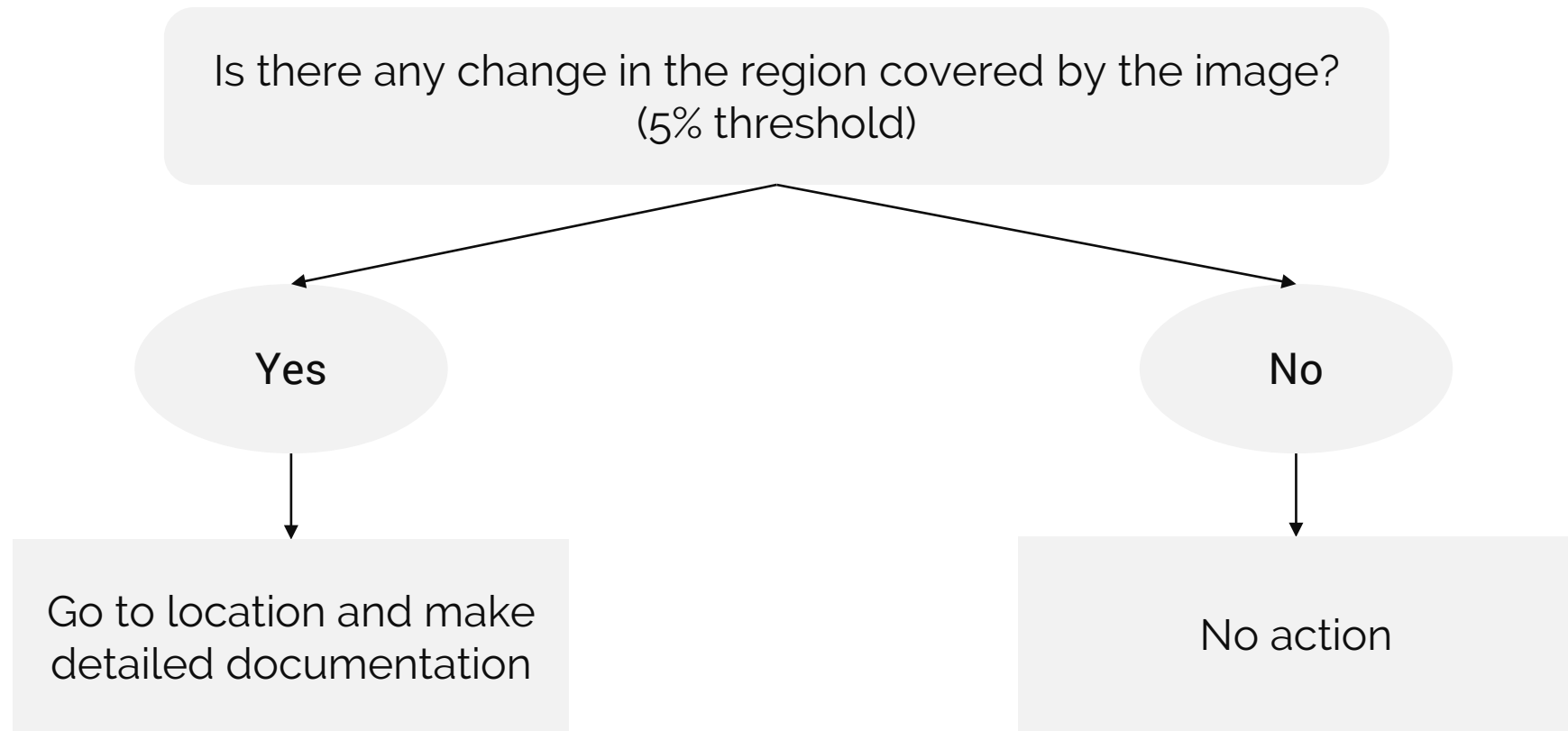
Reference dataset

6902 reference change maps (manual)



Experiment 1

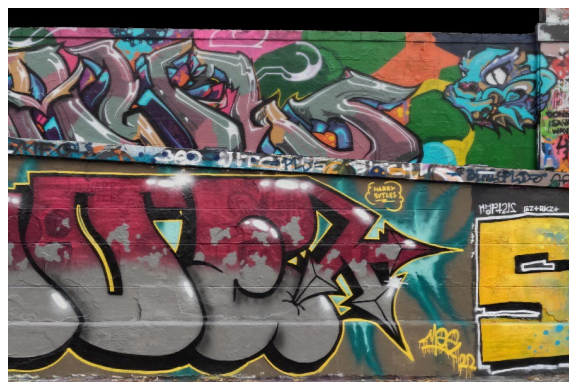
Binary classification of whole images



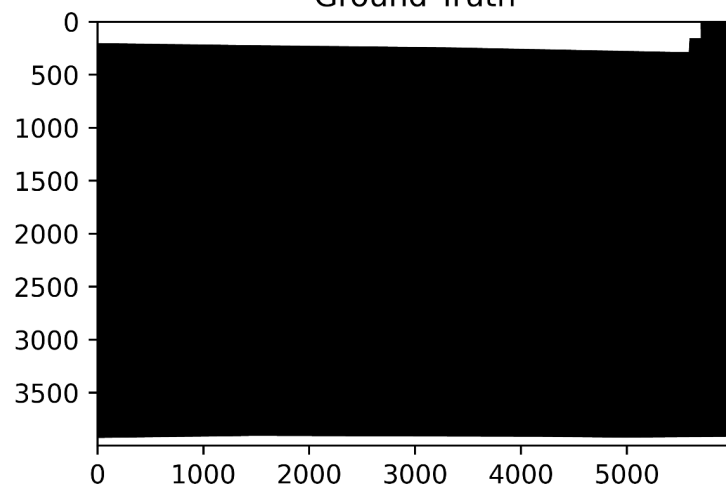
5930 of 6902 → 86% correct

Experiment 2

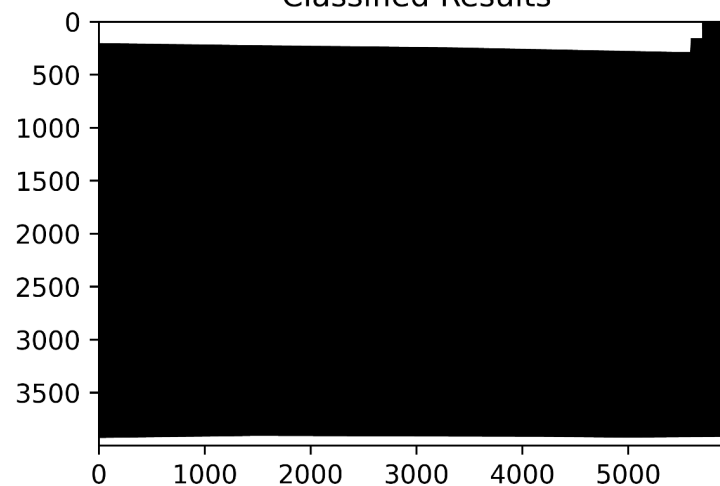
Pixel based metrics



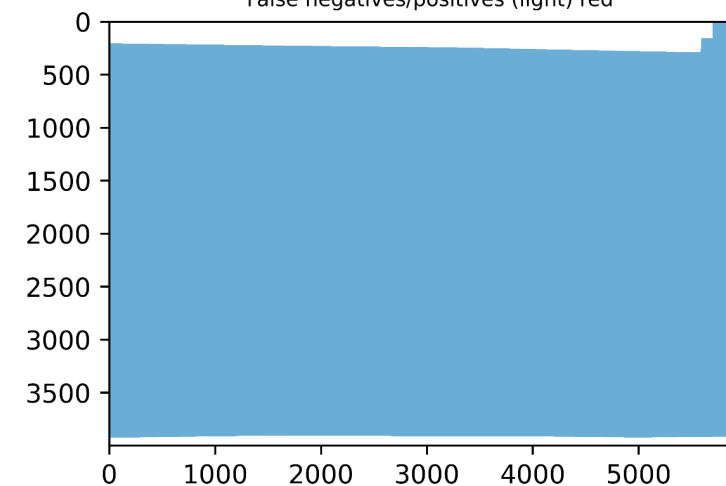
Ground Truth



Classified Results



True negatives/positives: (light) blue
False negatives/positives (light) red

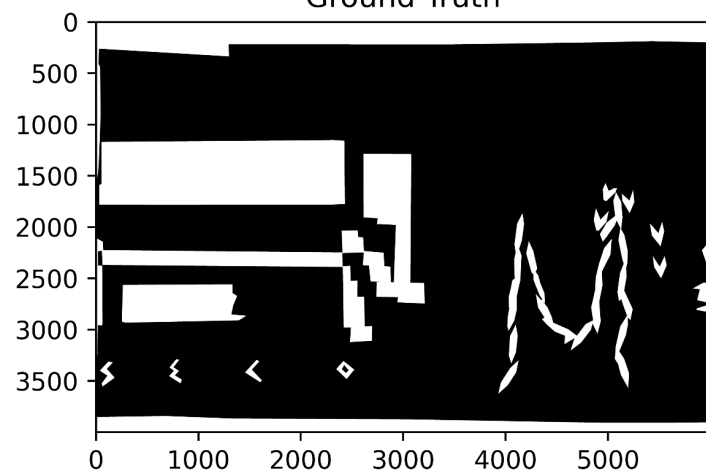


Experiment 2

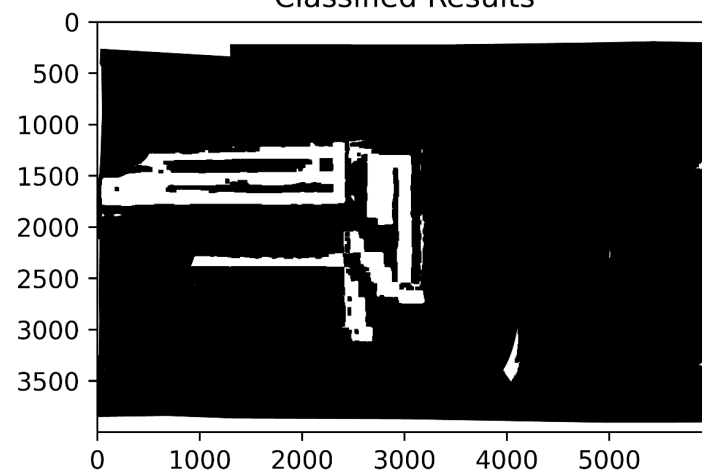
Pixel based metrics



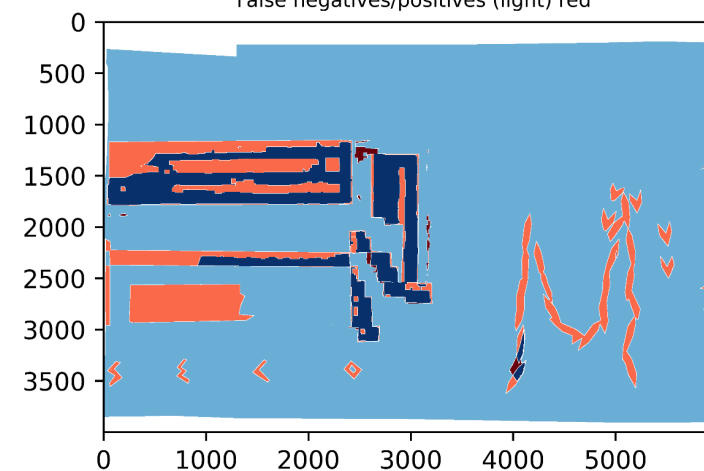
Ground Truth



Classified Results



True negatives/positives: (light) blue
False negatives/positives (light) red



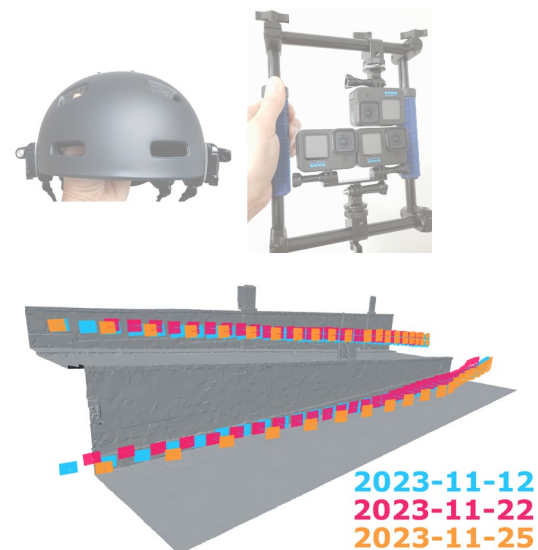
Conclusions

- **Fast image acquisition**



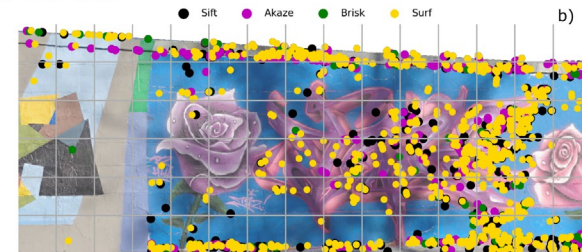
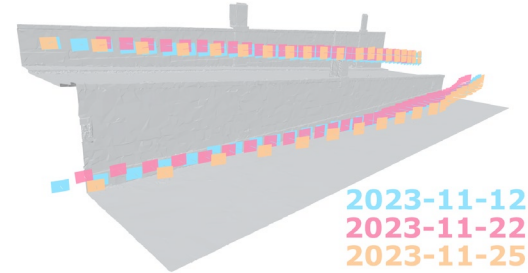
Conclusions

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



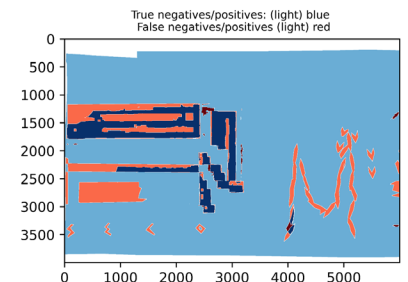
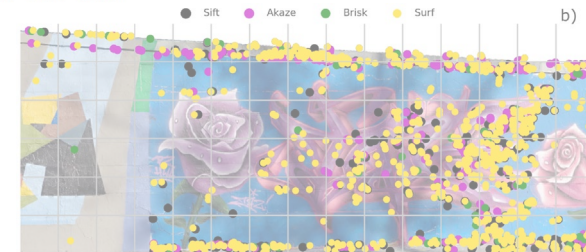
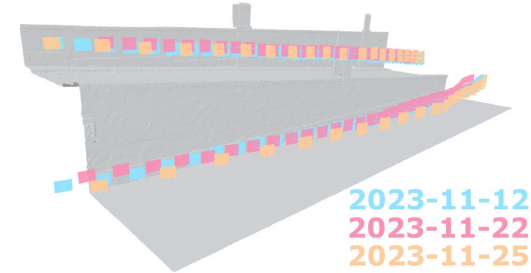
Conclusions

- 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 and monotone backgrounds**



Indigo



LUDWIG
BOLTZMANN
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Archaeological Prospection and Virtual Archaeology



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Wien



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