Towards the automatic production of graffiti orthophotos

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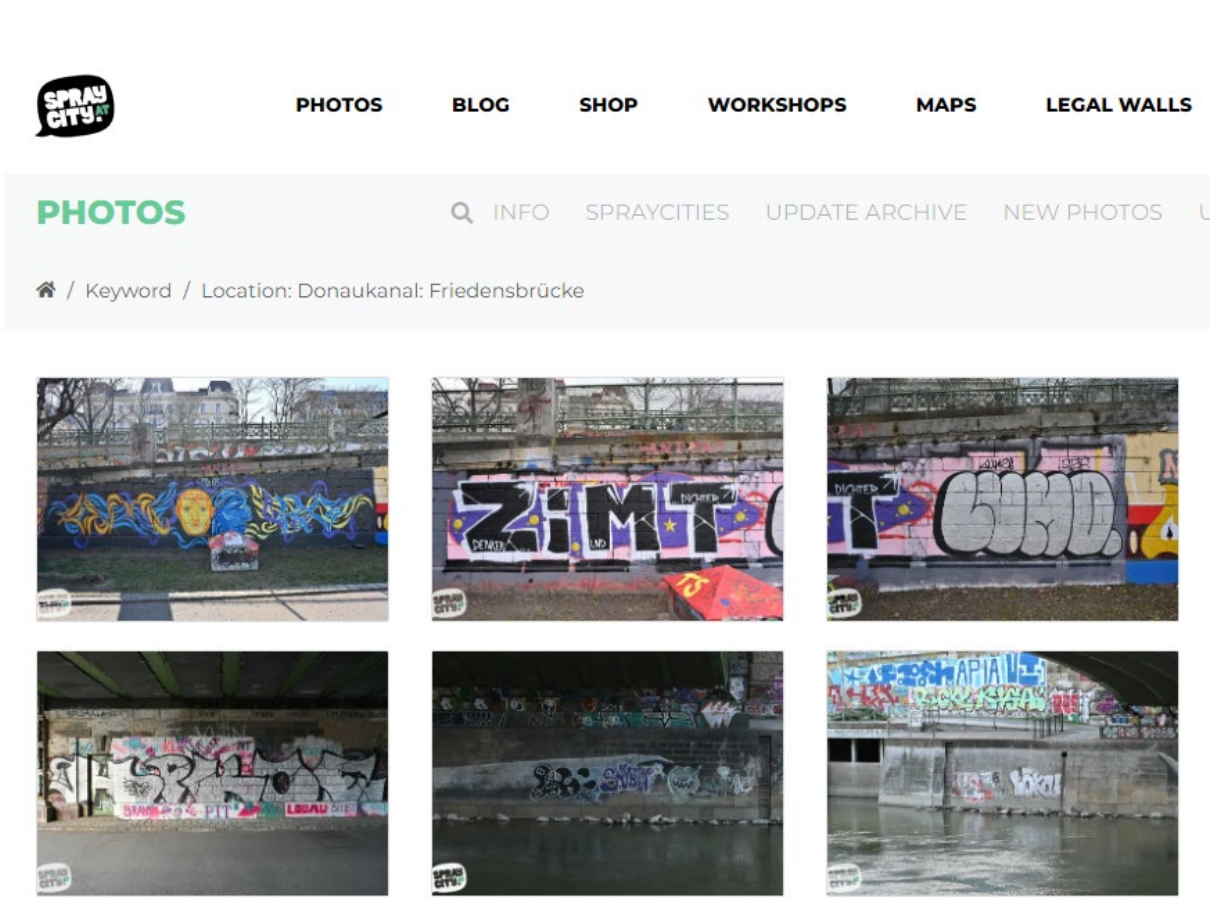
The INDIGO graffiti project is funded by the Heritage Science Austria programme of the Austrian Academy of Sciences (ÖAW)

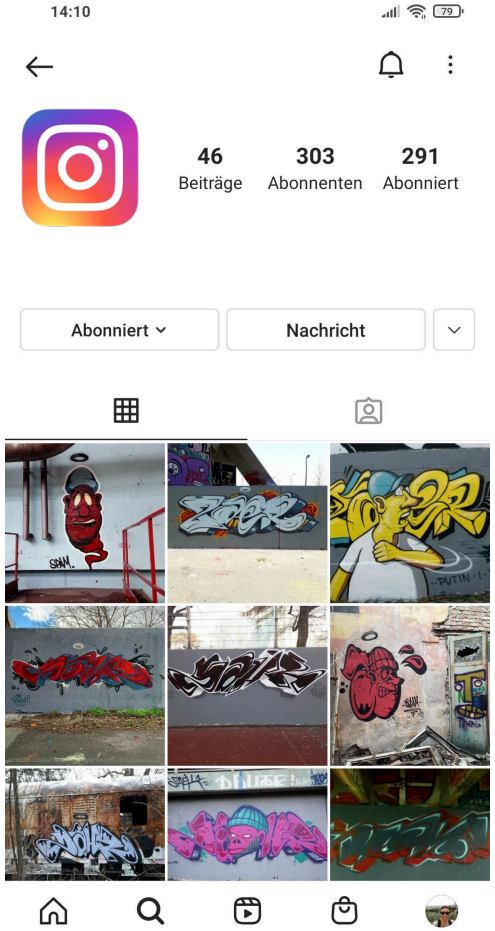
Engineering  **(Street-)Art**

Graffiti documentation?

Photos!

Graffiti documentation? Photos!





Photos? Orthophotos!

- Corrected for image distortions
  - Perspective
  - Topography
  - Lens

- Georeferenced
  - Locate it in 3D-space
  - Measure proportions

Why Orthophotos?

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- Distortions
  - Perspective

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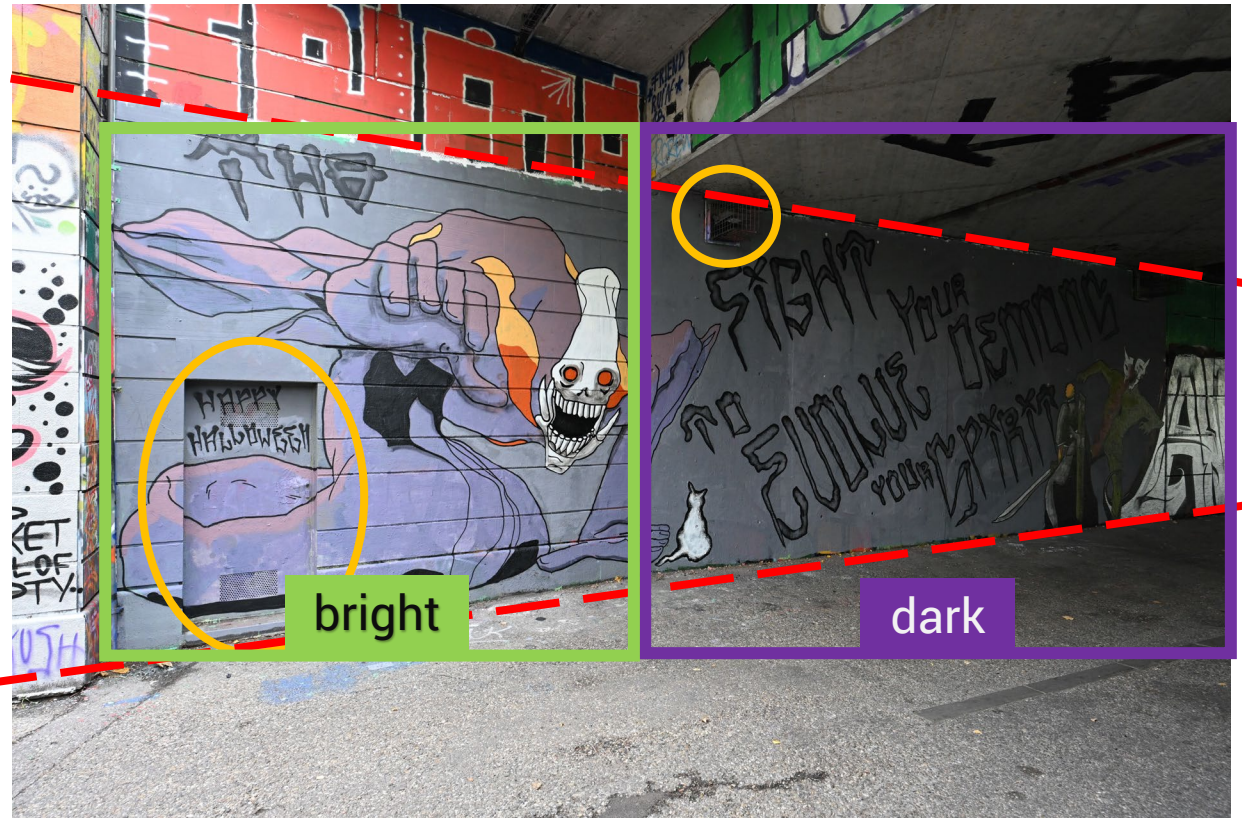

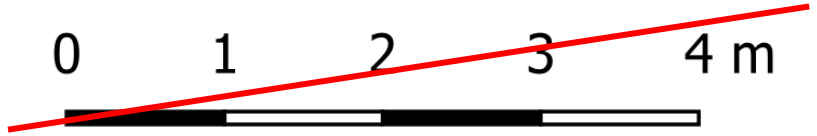

- Distortions
  - Perspective
  - Topography
  - Lens distortions
- Georeferenced
  - Locate it in space
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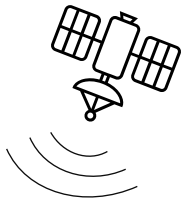
Orthophoto = Map

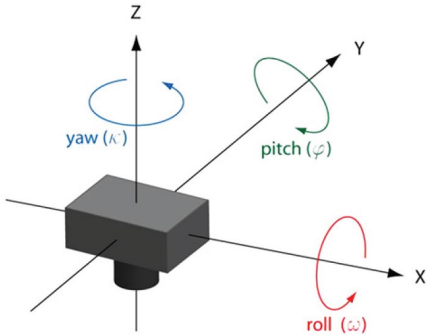
Data source: Stadt Wien – data.wien.gv.at

Orthophoto recipe

Camera orientation + 3D model + Projection plane

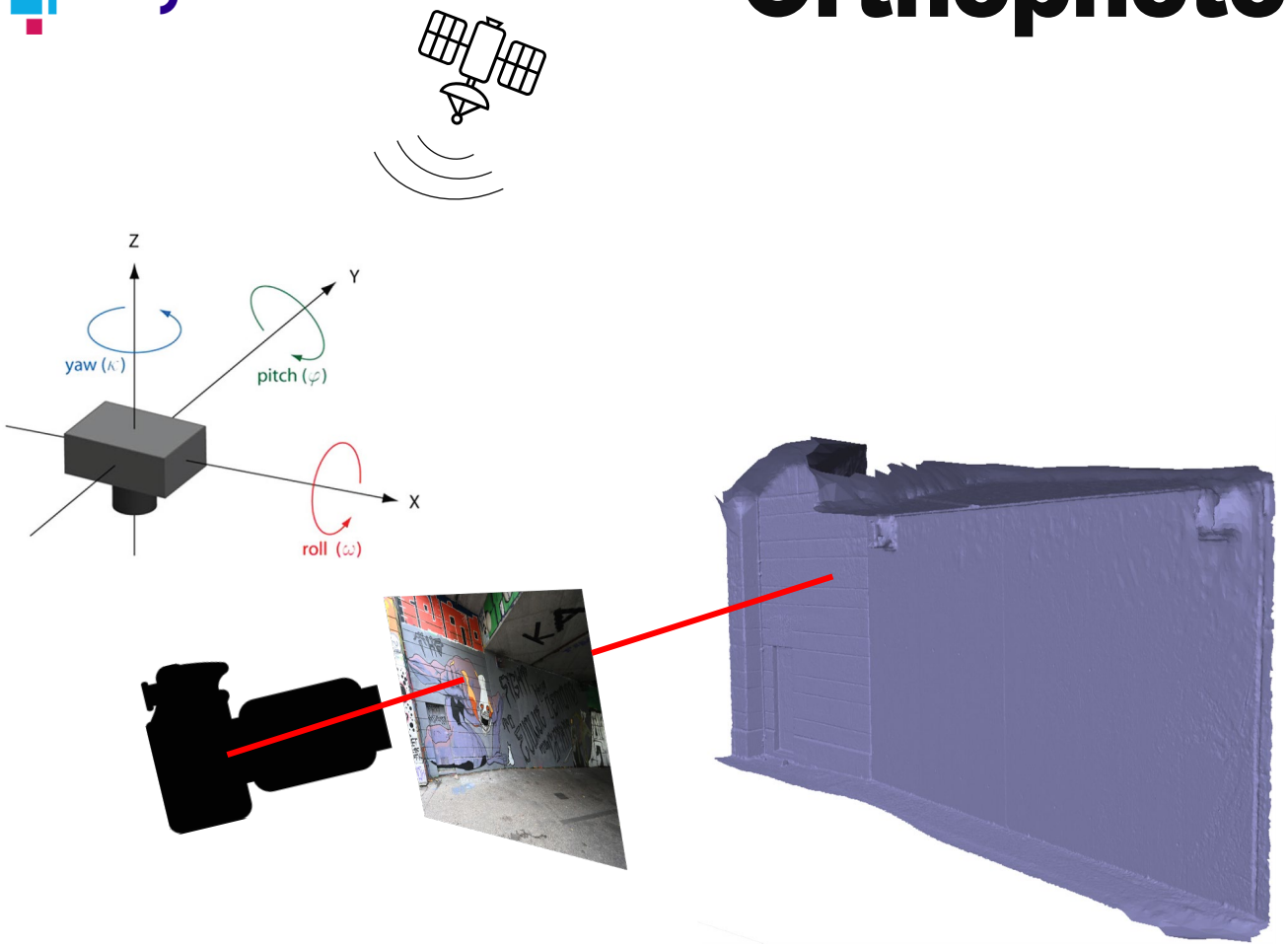
Orthophoto recipe





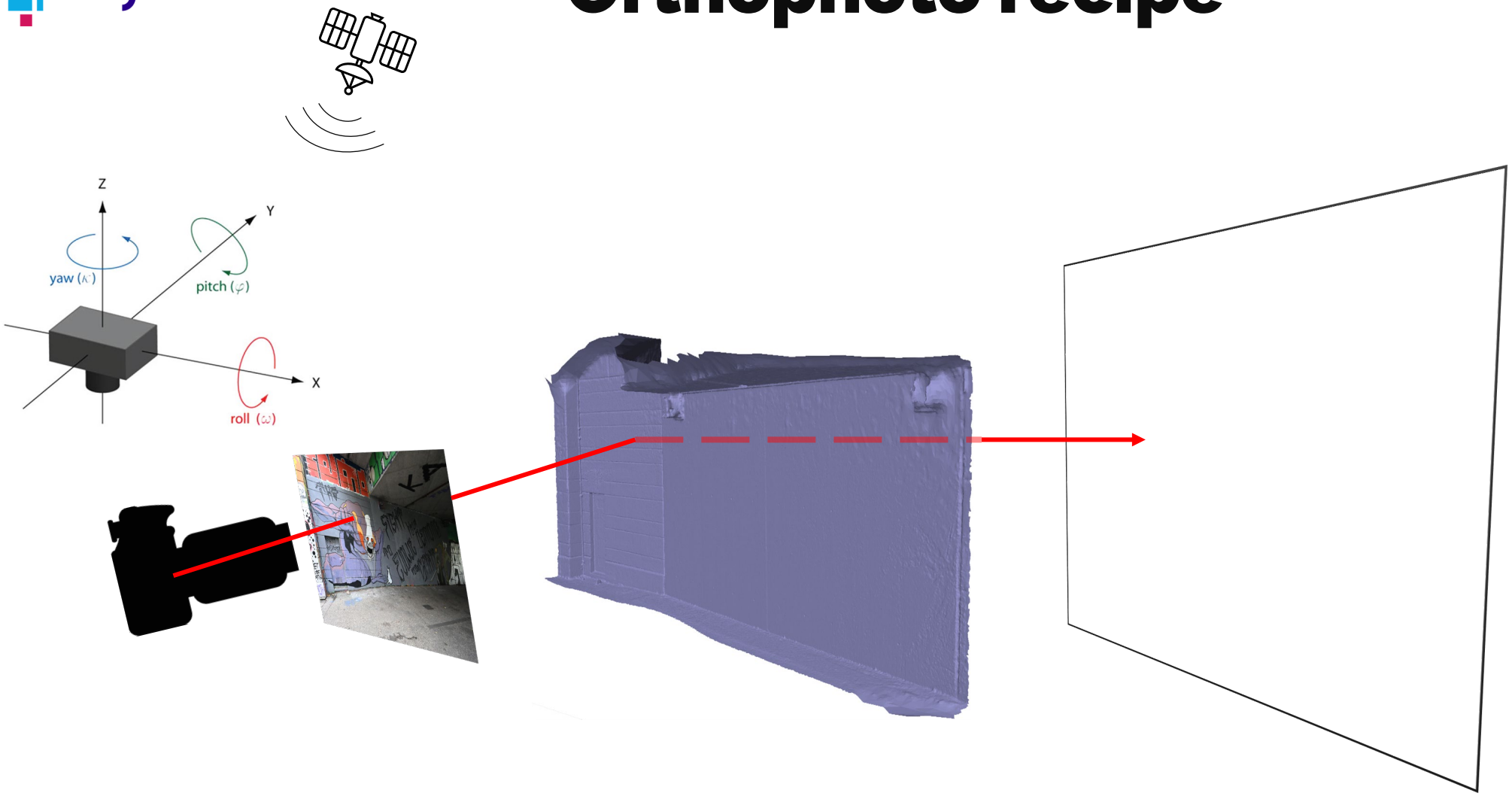
Camera orientation

Orthophoto recipe



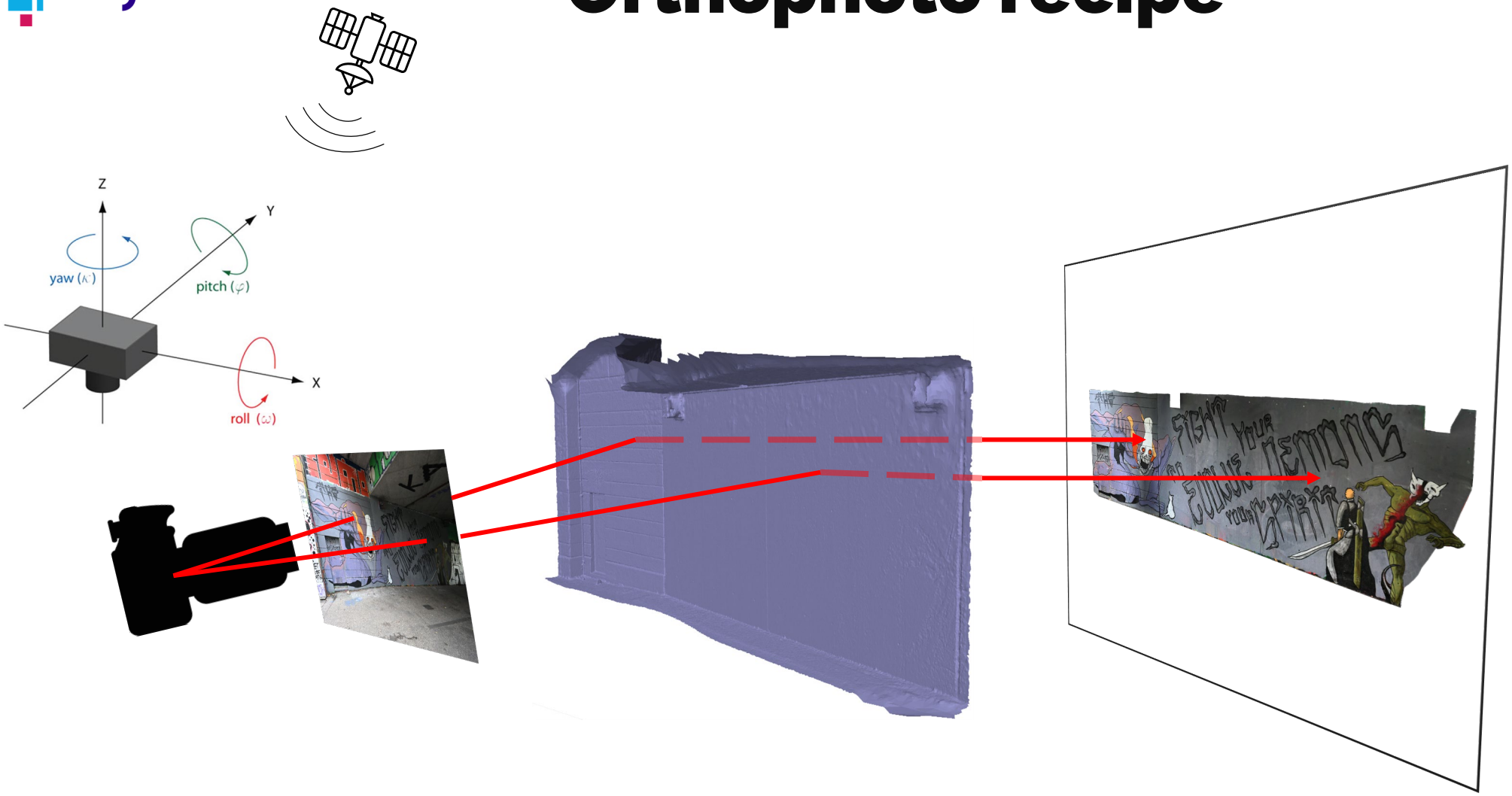
Camera orientation + **3D model**

Orthophoto recipe



Camera orientation + **3D model** + **Projection plane**

Orthophoto recipe



Camera orientation + **3D model** + **Projection plane**

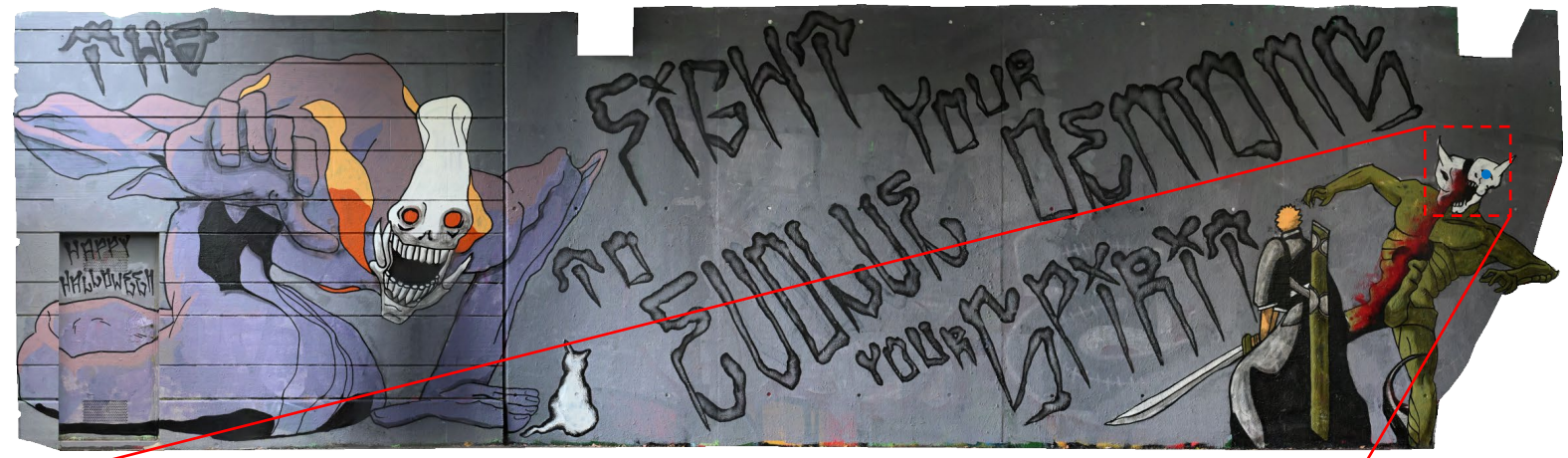
Orthophoto recipe

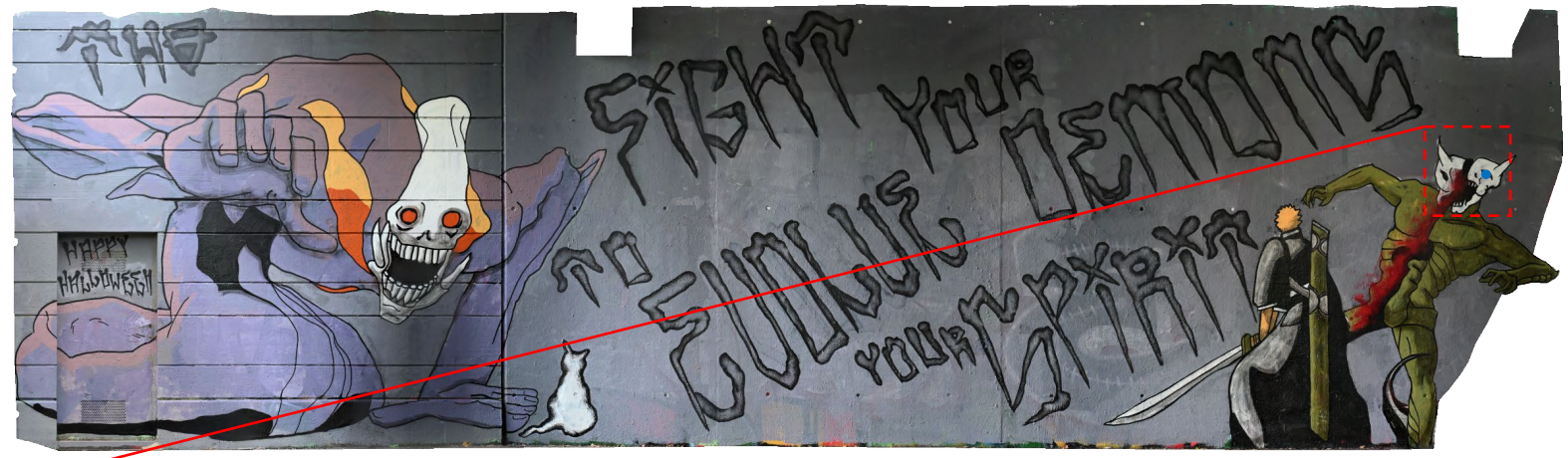
Perimeter	**36.82 m**
Area	**51.2 m²**


INDIGO_2022_11_13
Research area
0
250
500 m
EPSG: 31256 (MGI / Austria GK East)


INDIGO_2022_11_13
Research area
0
10
20 m
EPSG: 31256 (MGI / Austria GK East)


INDIGO_2022_11_13
Research area
0
10
20 m
EPSG: 31256 (MGI / Austria GK East)


THE
FIGHT
TO FIND YOUR DEMONS
YOUR SPIRIT
HAPPY
HALLOWEEN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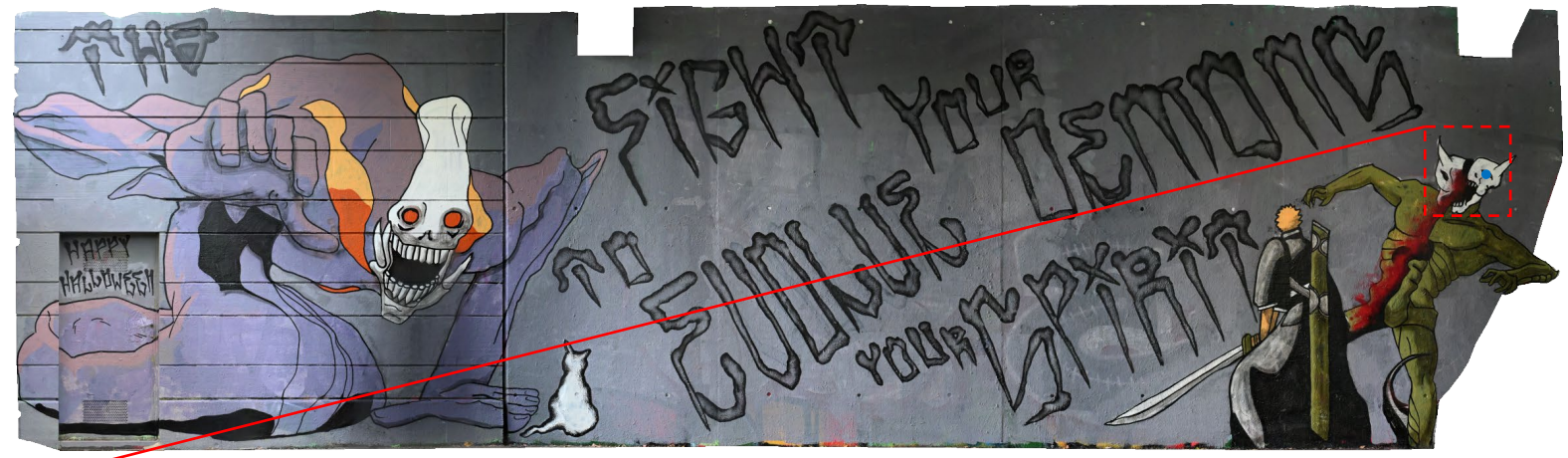
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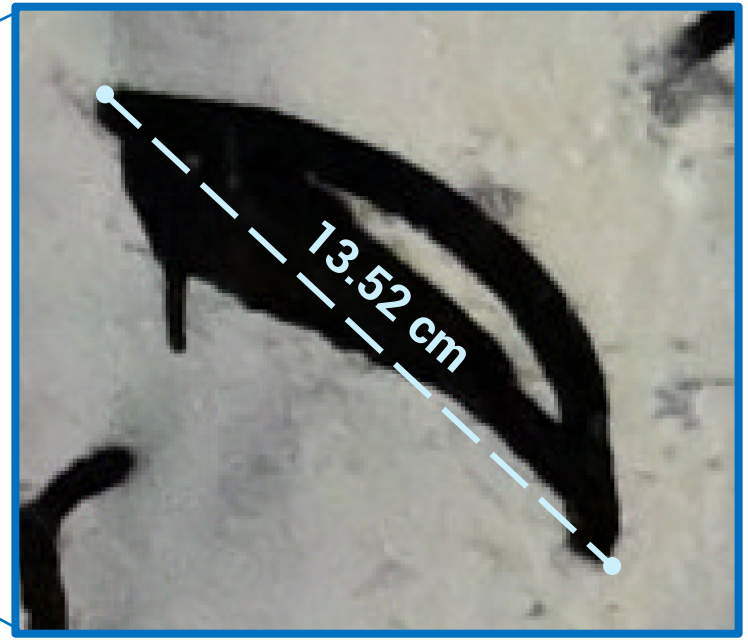

13.52 cm


HAPPY
HALLOWEEN
TO FIGHT YOUR DEMONS YOUR SPIRIT


0
1
2
3
4 m
HAPPY
HALLOWEEN
TO FIGHT YOUR DEMONS YOUR SPIRIT
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14 m

Advantages

vs.

Effort

Ca. 10 images of a new graffito (different viewing directions/tilts/positions)


INDIGO_2021-12-28_Z7II-B_0292.jpg


INDIGO_2021-12-28_Z7II-B_0293.jpg


INDIGO_2021-12-28_Z7II-B_0294 - Copy.jpg


INDIGO_2021-12-28_Z7II-B_0294.jpg


INDIGO_2021-12-28_Z7II-B_0295.jpg

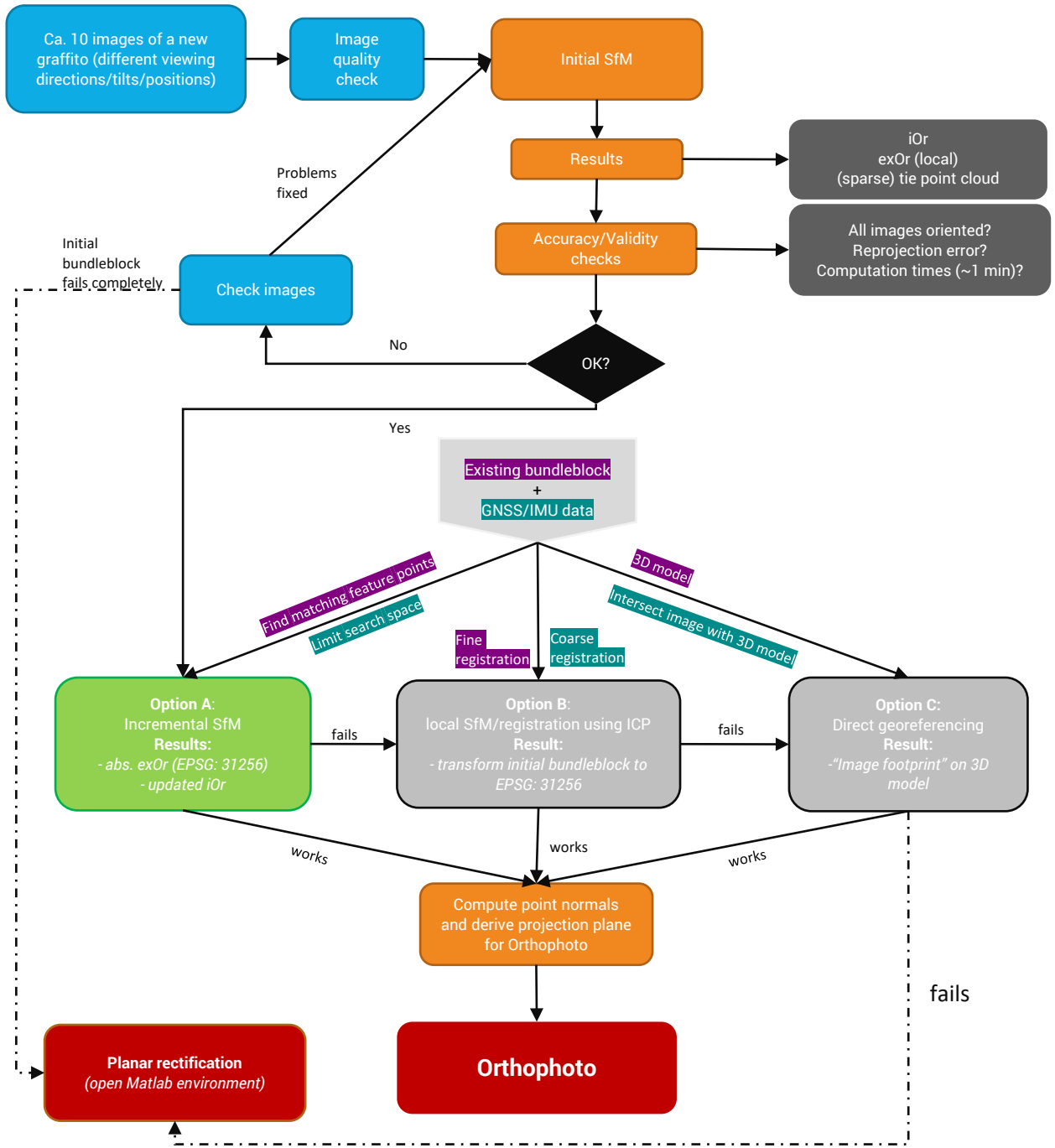

INDIGO_2021-12-28_Z7II-B_0296.jpg

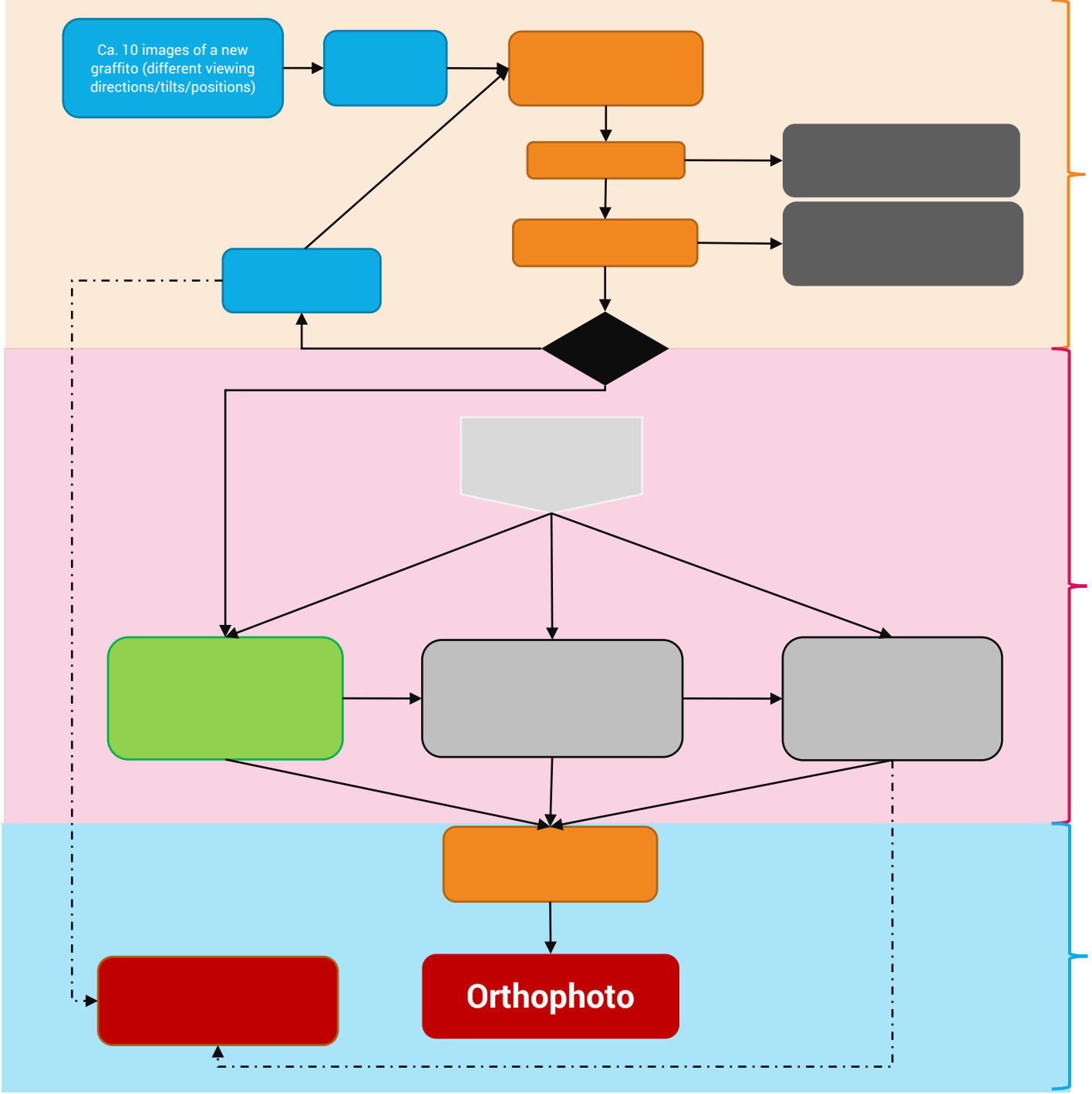

INDIGO_2021-12-28_Z7II-B_0297.jpg

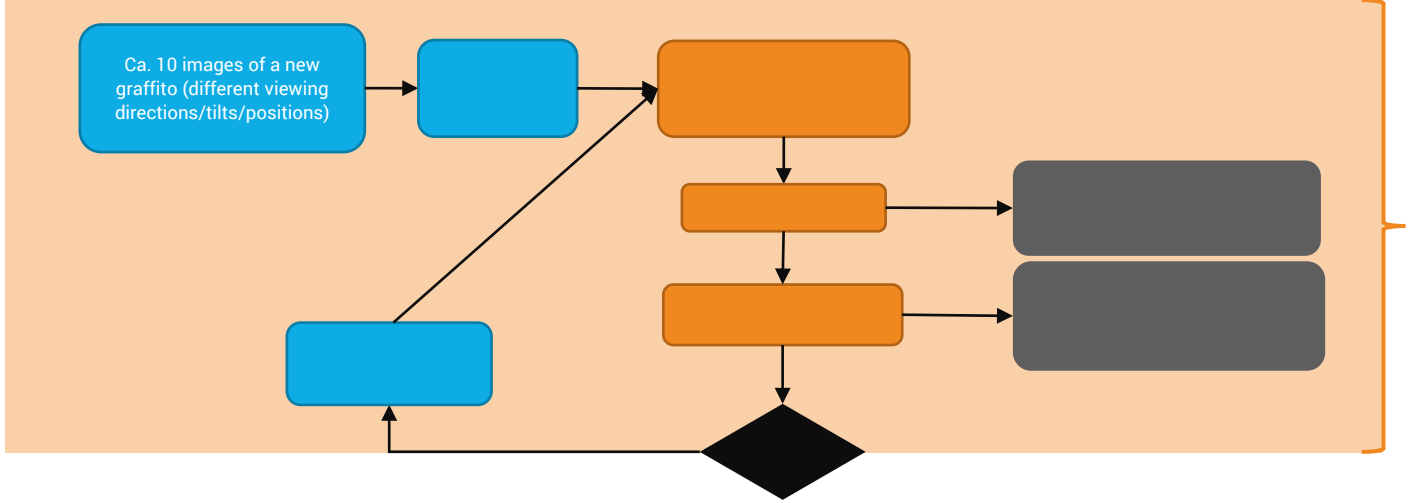

INDIGO_2021-12-28_Z7II-B_0298.jpg


INDIGO_2021-12-28_Z7II-B_0299.jpg

Orthophoto


Ca. 10 images of a new graffito (different viewing directions/tilts/positions)
Image quality check
Initial SfM
Results
iOr
exOr (local)
(sparse) tie point cloud
Problems fixed
Accuracy/Validity checks
All images oriented?
Reprojection error?
Computation times (~1 min)?
Initial bundleblock fails completely
Check images
No
OK?
Yes
Existing bundleblock
+
GNSS/IMU data
Find matching feature points
Limit search space
Fine registration
Coarse registration
3D model
Intersect image with 3D model
Option A:
Incremental SfM
Results:
- abs. exOr (EPSG: 31256)
- updated iOr
fails
Option B:
local SfM/registration using ICP
Result:
- transform initial bundleblock to EPSG: 31256
fails
Option C:
Direct georeferencing
Result:
-"Image footprint" on 3D model
works
works
works
Compute point normals and derive projection plane for Orthophoto
fails
Planar rectification
(open Matlab environment)
Orthophoto


Ca. 10 images of a new graffito (different viewing directions/tilts/positions)
Orthophoto
Initial checks
Camera Orientations
Incremental SfM
Orthophoto



Initial checks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INDIGO_2021-12-28_Z7II-B_0294 - Copy.jpg


INDIGO_2021-12-28_Z7II-B_0294.jpg


INDIGO_2021-12-28_Z7II-B_0295.jpg

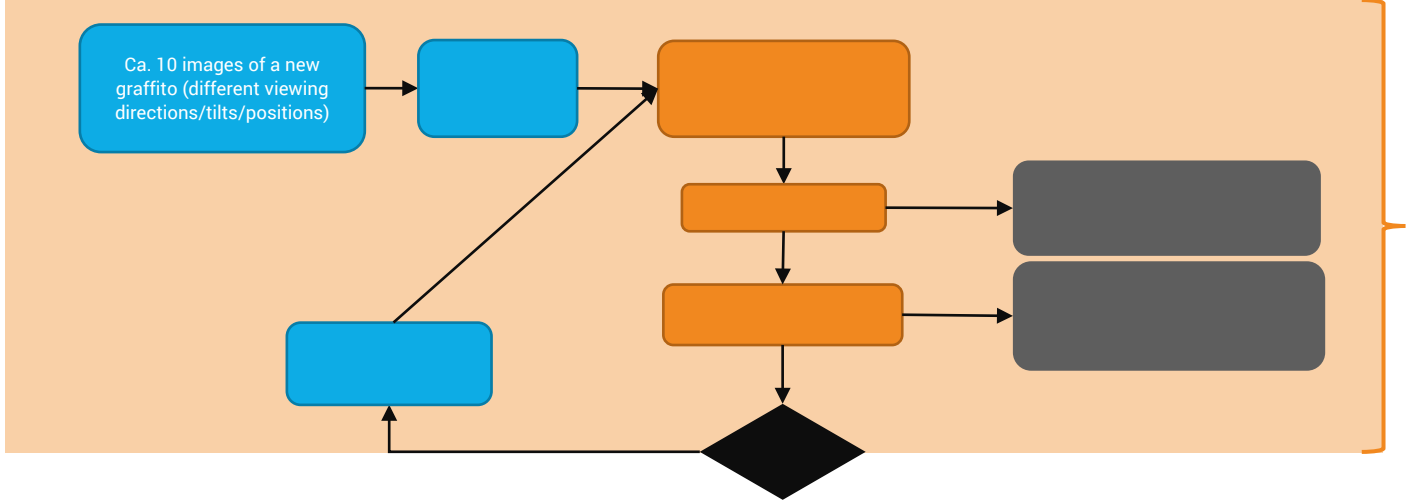

INDIGO_2021-12-28_Z7II-B_0296.jpg


INDIGO_2021-12-28_Z7II-B_0296a.jpg


INDIGO_2021-12-28_Z7II-B_0297.jpg


INDIGO_2021-12-28_Z7II-B_0298.jpg


INDIGO_2021-12-28_Z7II-B_0300.jpg



Initial checks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INDIGO_2021-12-28_Z7II-B_0293.jpg


INDIGO_2021-12-28_Z7II-B_0294 - Copy.jpg


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INDIGO_2021-12-28_Z7II-B_0295.jpg

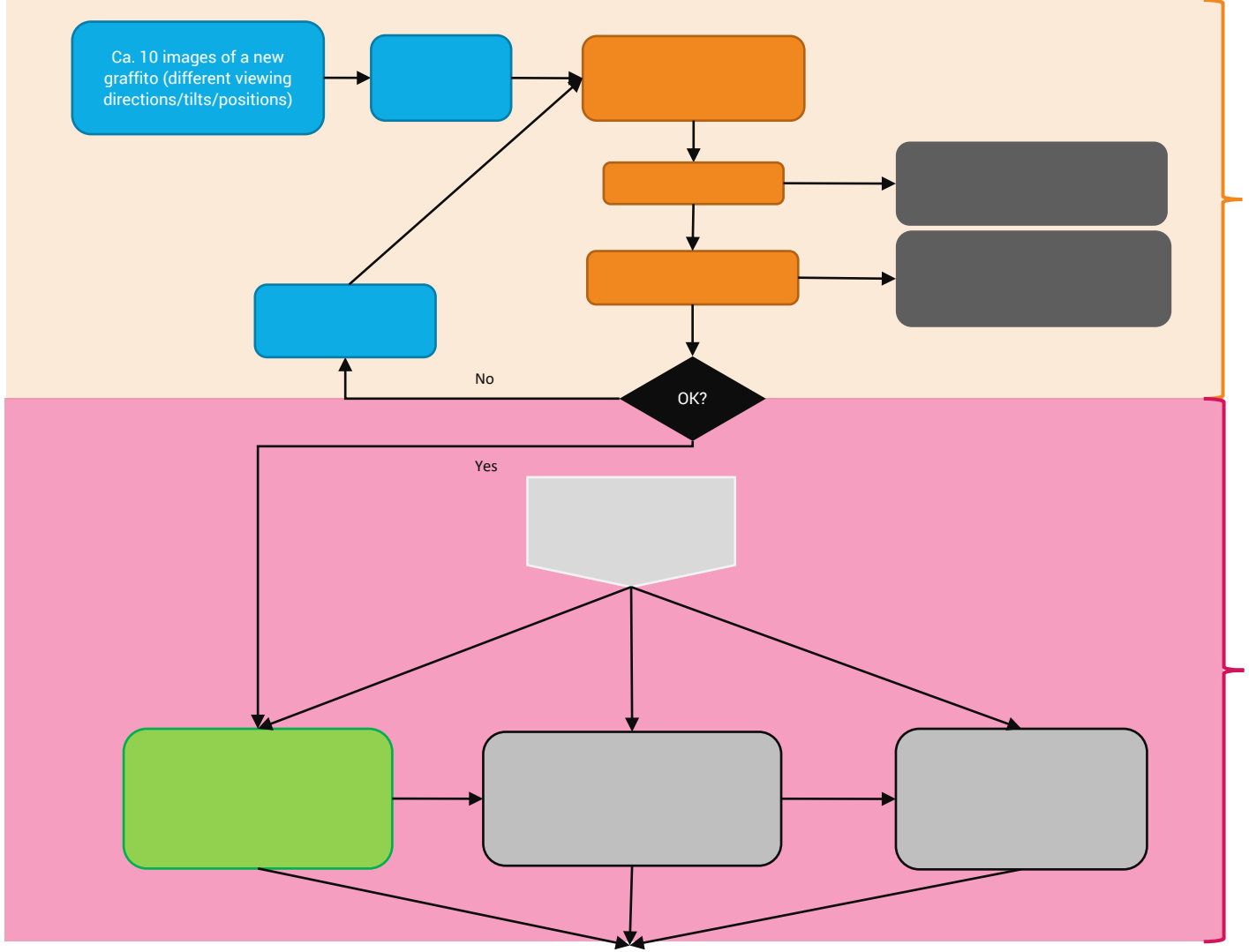

INDIGO_2021-12-28_Z7II-B_0296.jpg


INDIGO_2021-12-28_Z7II-B_0296a.jpg


INDIGO_2021-12-28_Z7II-B_0297.jpg


INDIGO_2021-12-28_Z7II-B_0298.jpg


INDIGO_2021-12-28_Z7II-B_0300.jpg



Initial checks

Camera Orientations

Incremental SfM

SfM

- **SfM = Structure from Motion**
  - 3D - reconstruction of objects from 2D images

Verhoeven et al., 2022

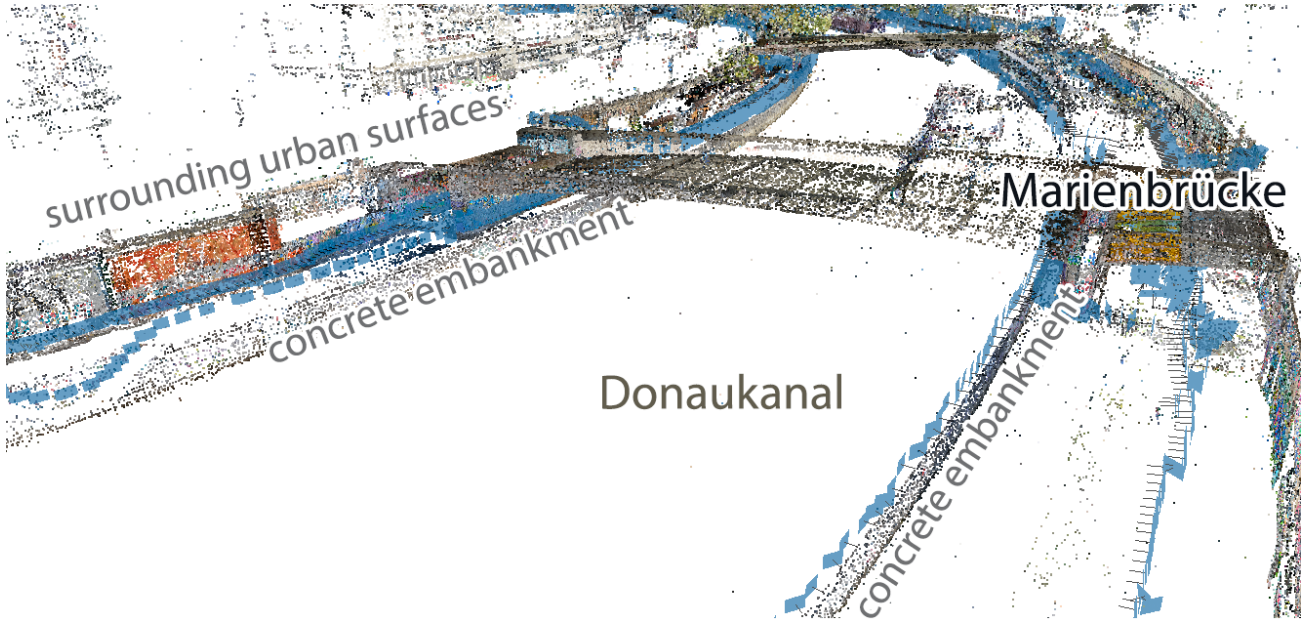
SfM

- **SfM = Structure from Motion**
  - 3D - reconstruction of objects from 2D images
  - Result: point cloud („**tie points**“) and network camera orientations.

Photo A Photo B

SfM

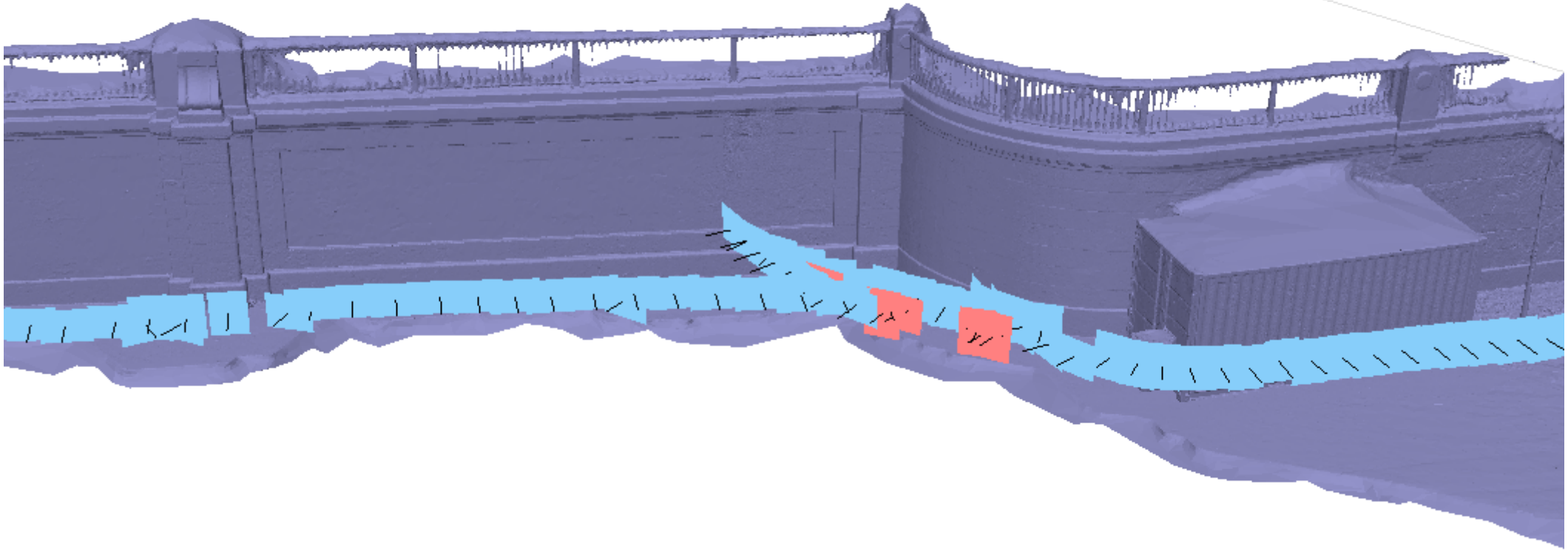
- **SfM = Structure from Motion**
  - 3D - reconstruction of objects from 2D images
  - Result: point cloud („tie points“) and network of camera orientations.



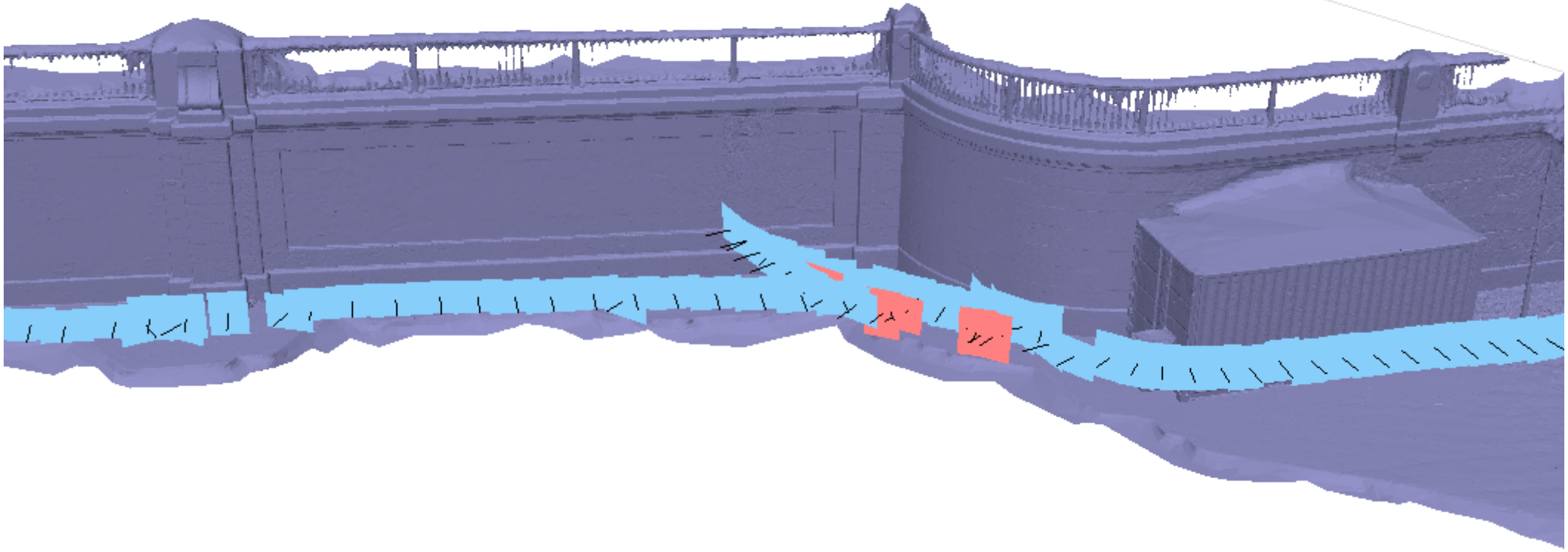
Verhoeven et al., 2022

  - High overlap of images required
  - „full photographic coverage“ in autumn 2021

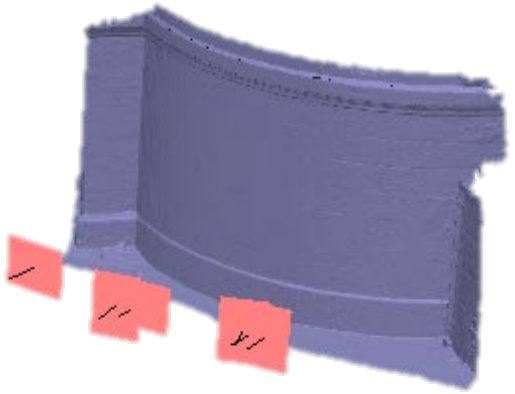
Incremental SfM



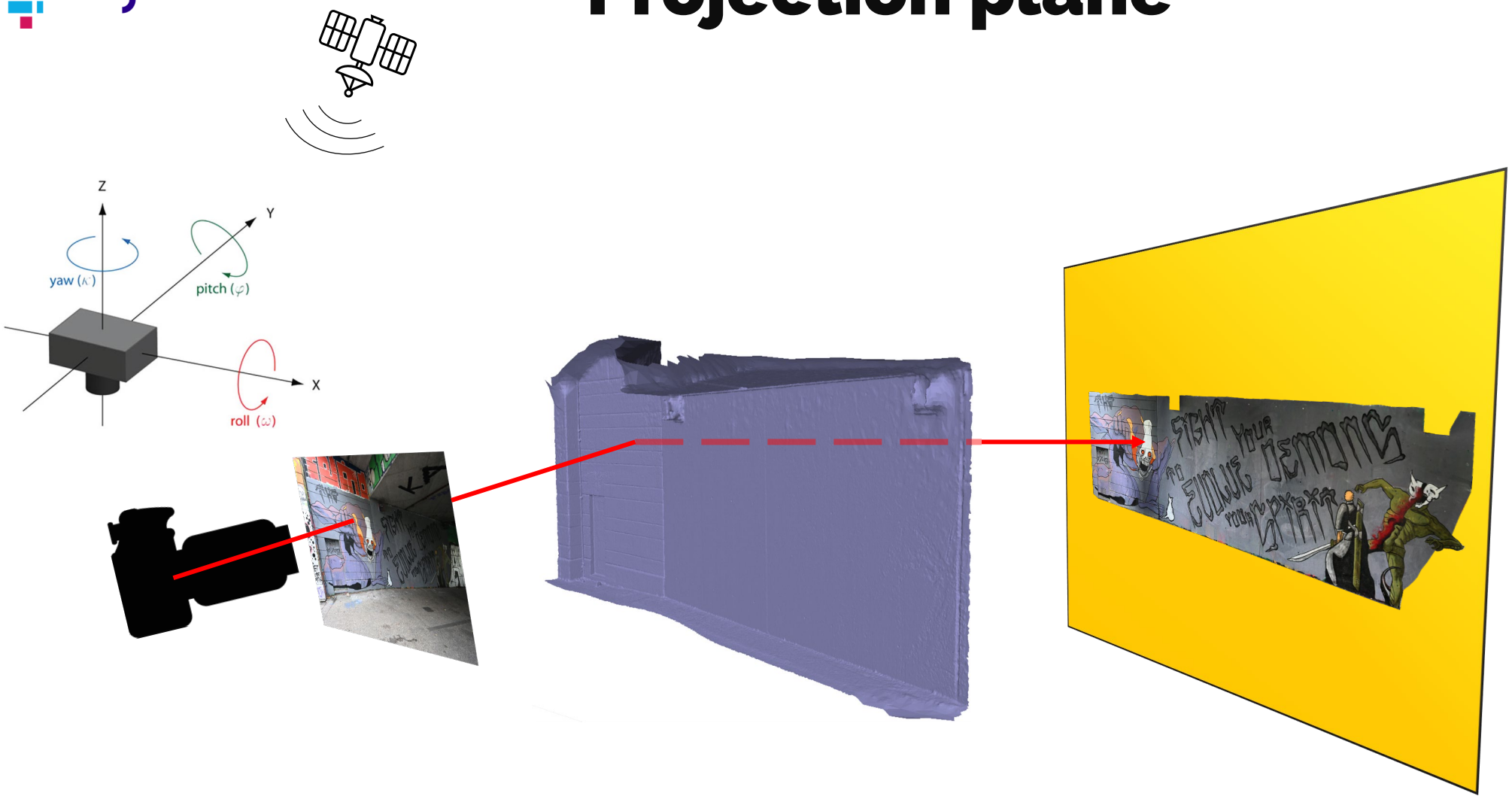
3D Model



3D Model

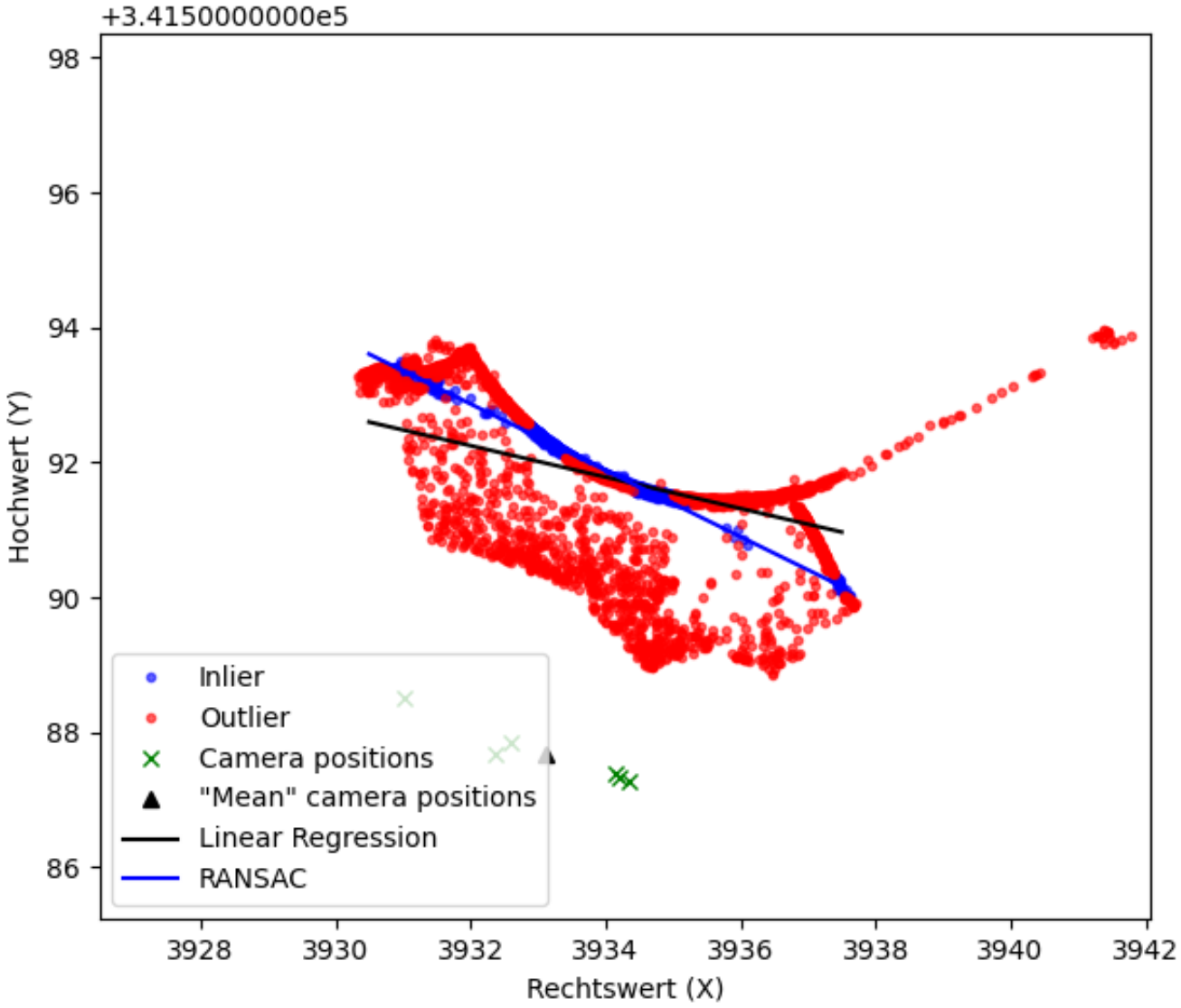


Projection plane

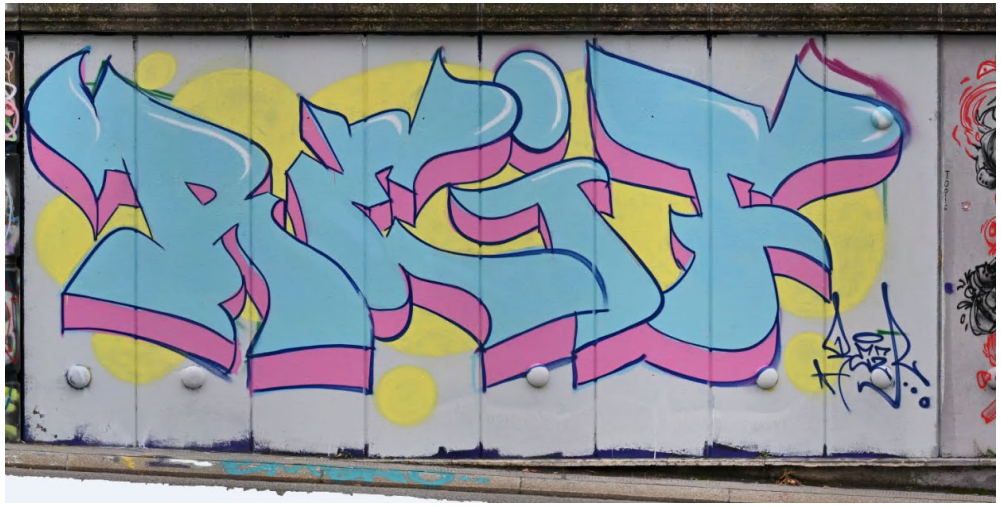


Camera orientation ✓ + 3D model ✓ + **Projection plane**

Projection plane



One click = Hundreds of Orthophoto



Challenges

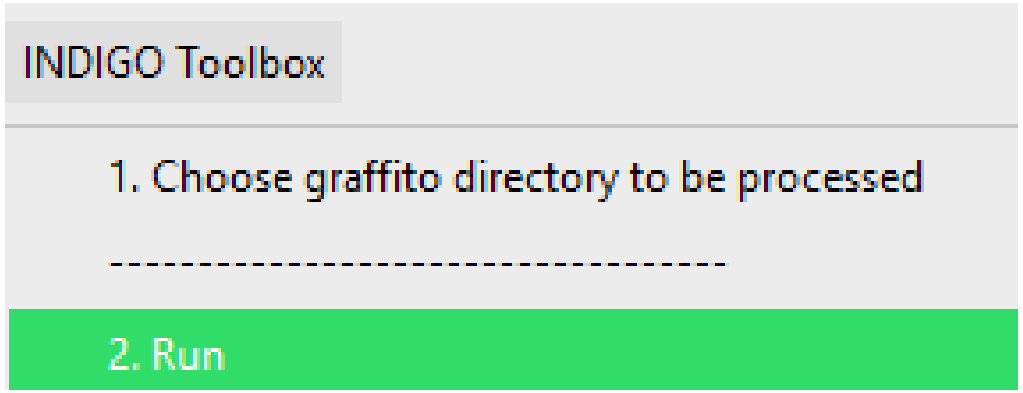
- Approach fails when:
  - occlusions occur
  - camera orientations are wrong
  - graffiti are sprayed around corners

- Processing times:
  - ca. 70 graffiti per day
  - Solution: more accurate GNSS/IMU

Python „One-touch“ Toolbox

python™

Metashape



Conclusions

- Many advantages of Orthophotos

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- **Challenging to derive**

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- Challenging to derive
- **Automated open source tool**

Conclusions

- Many advantages of Orthophotos
- Challenging to derive
- Automated open source tool
- **Further improvements**

indigo

ÖAW

GiFLE

TU WIEN GEO

vrvis

Stadt Wien

SPRAY CITY.AT

LUDWIG BOLTZMANN INSTITUTE
Archaeological Prospection and Virtual Archaeology

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