

3D BAG

GE01004: 3D modelling of the built environment

Ravi Peters

06-03-2024



3D geoinformation

Department of Urbanism
Faculty of Architecture and the Built Environment
Delft University of Technology



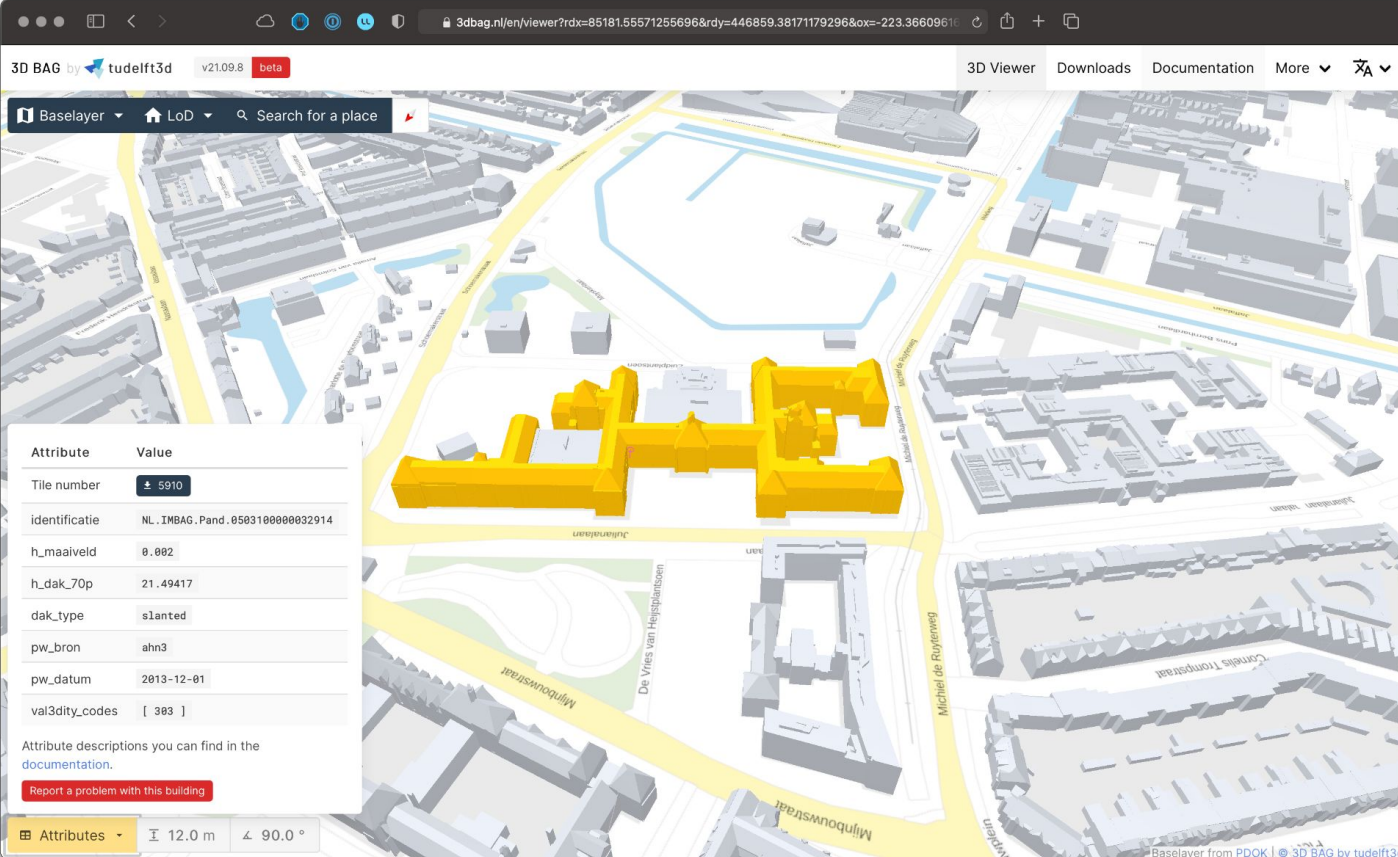
3DGI



The 3D BAG

3dbag.nl

Data:  



3D BAG by tudelft3d v21.09.8 beta

Baselayer | LoD | Search for a place

Attribute	Value
Tile number	5910
identificatie	NL_IMBAG_Pand.0593100000032914
h_maaiveld	0.002
h_dak_70p	21.49417
dak_type	s1anted
pw_bron	ahn3
pw_datum	2013-12-01
val3dity_codes	[383]

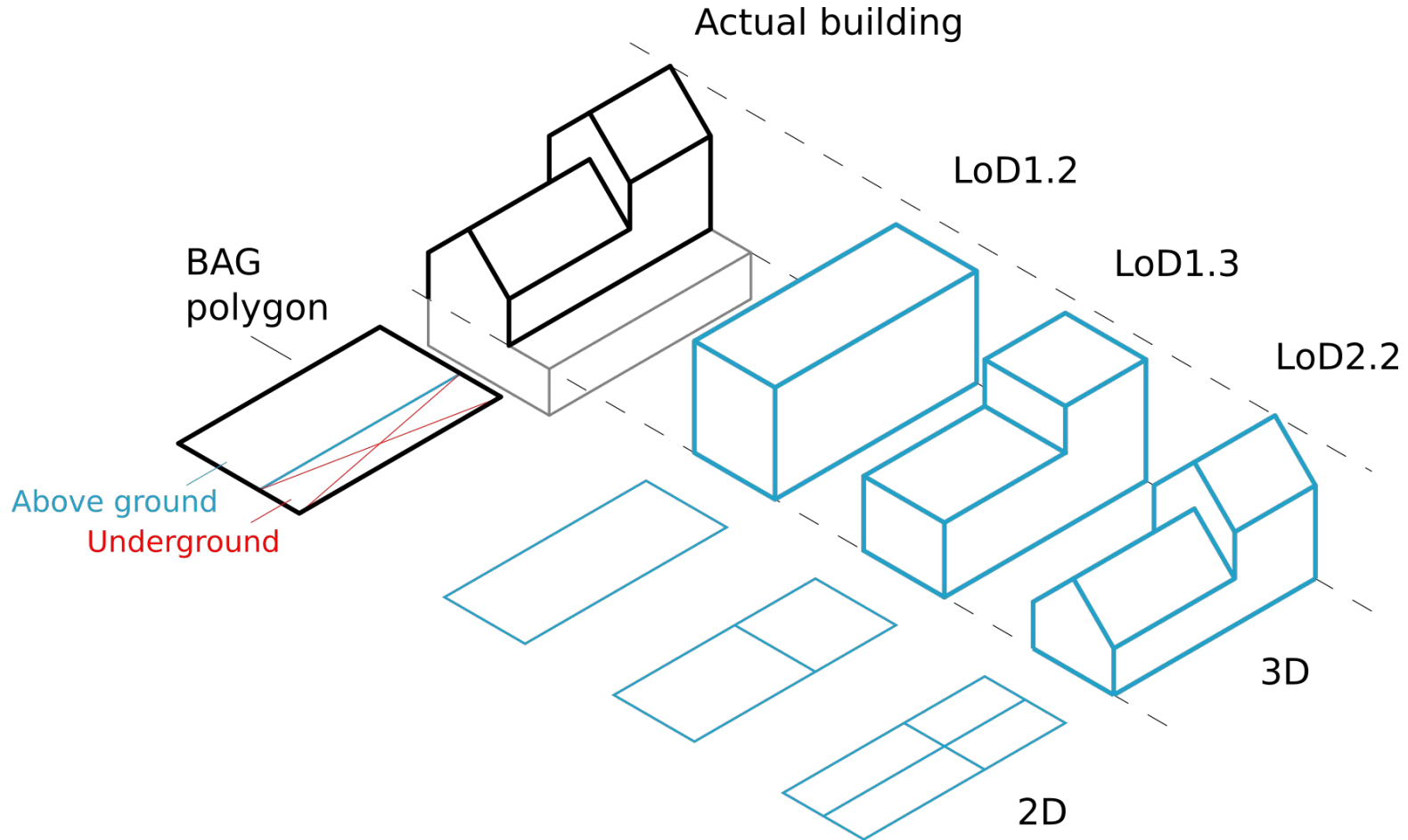
Attribute descriptions you can find in the [documentation](#).

[Report a problem with this building](#)

Attributes | 12.0 m | 90.0°

Baselayer from PDOK | 3D BAG by tudelft3d

3D BAG layers: 3 LoDs



A bit of background...

- Developed in 3D geoinformation group
- Prior to v2 we had v1
 - Only LoD1.2
 - Used by practitioners, much feedback
- Co-developments within several research projects
 - Initial request for LoD1.3 models for Noise simulation NL



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Rijkswaterstaat
Ministerie van Infrastructuur en Milieu



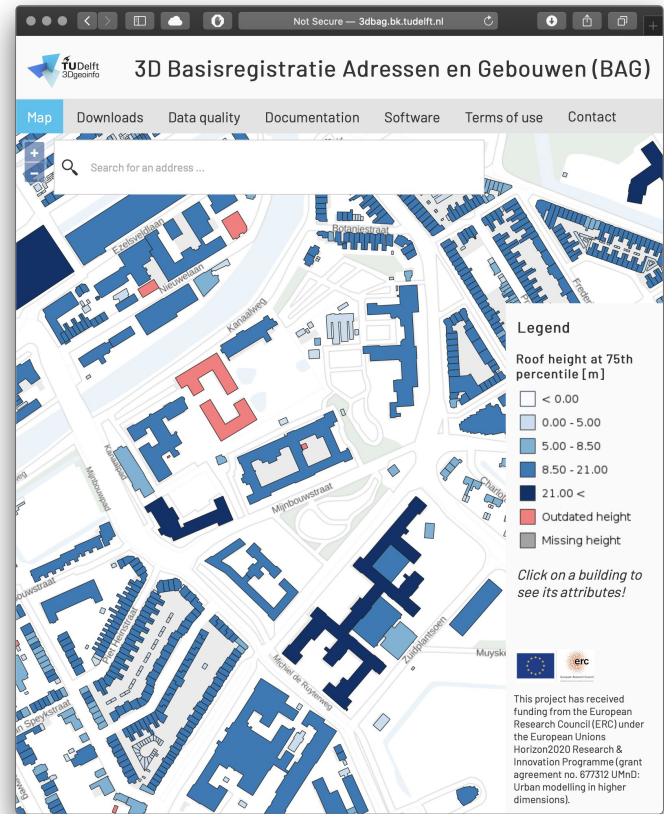
Rijksinstituut voor Volksgezondheid
en Milieu
Ministerie van Volksgezondheid,
Welzijn en Sport



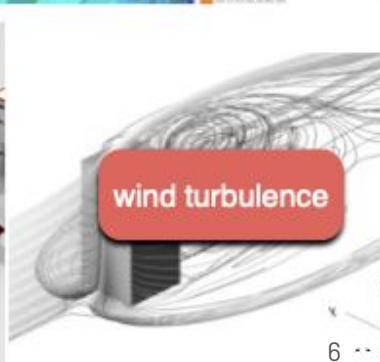
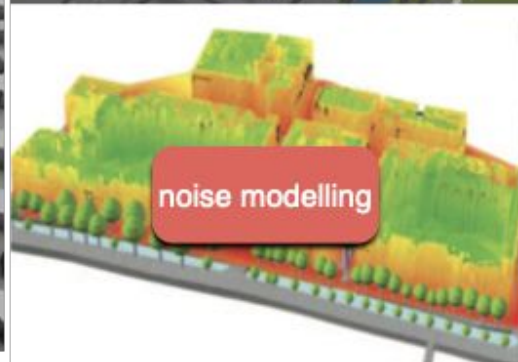
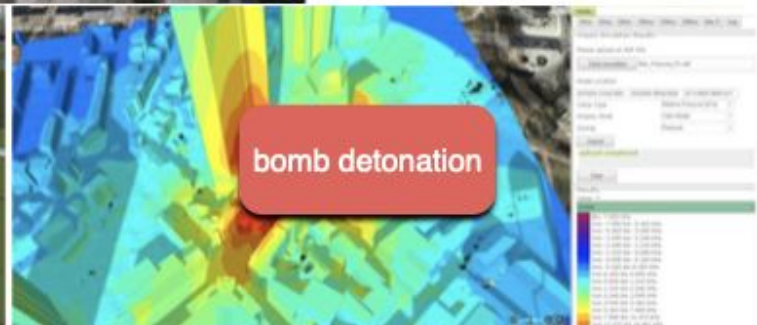
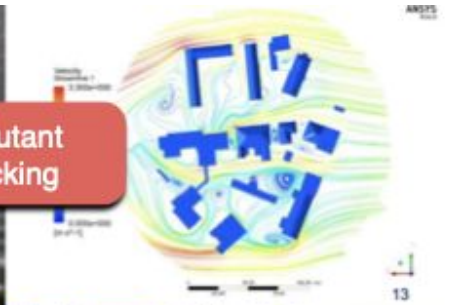
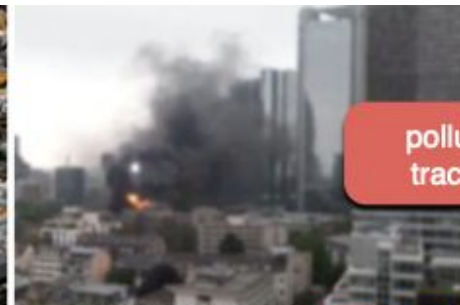
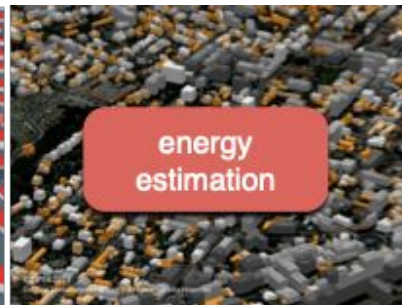
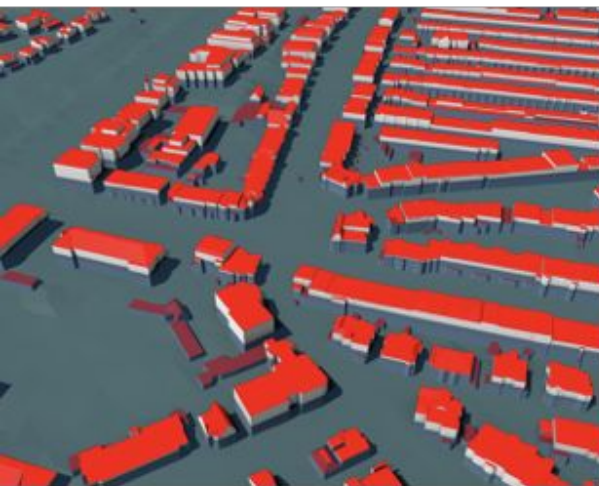
Interprovinciaal Overleg
van en voor provincies



European Research Council
Established by the European Commission



3DBAG v1





Heating energy demand

Computational Fluid Dynamics

Solar panel potential

Heating energy demand

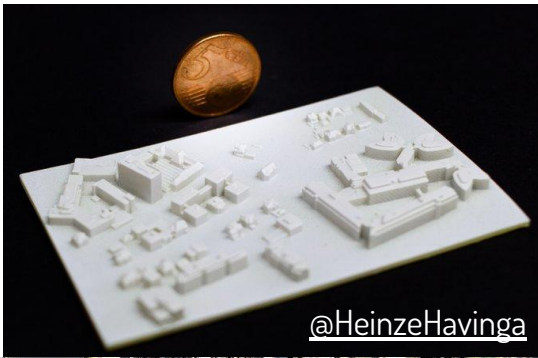
Computational Fluid Dynamics

Solar panel potential



3D BAG in practice

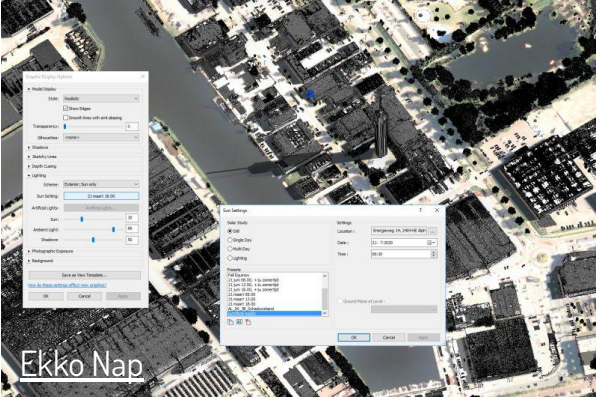
<https://docs.3dbag.nl/en/overview/media/>



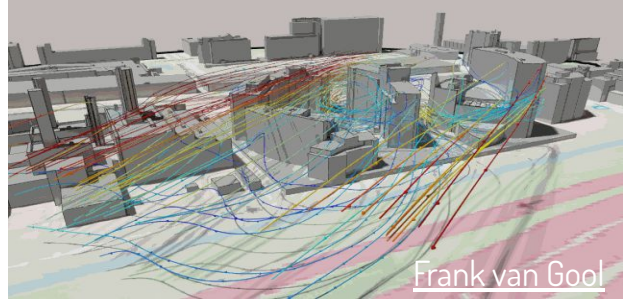
@HeinzeHavinga



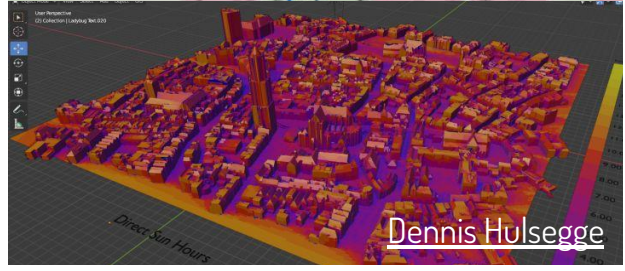
Tygron



Ekko Nap



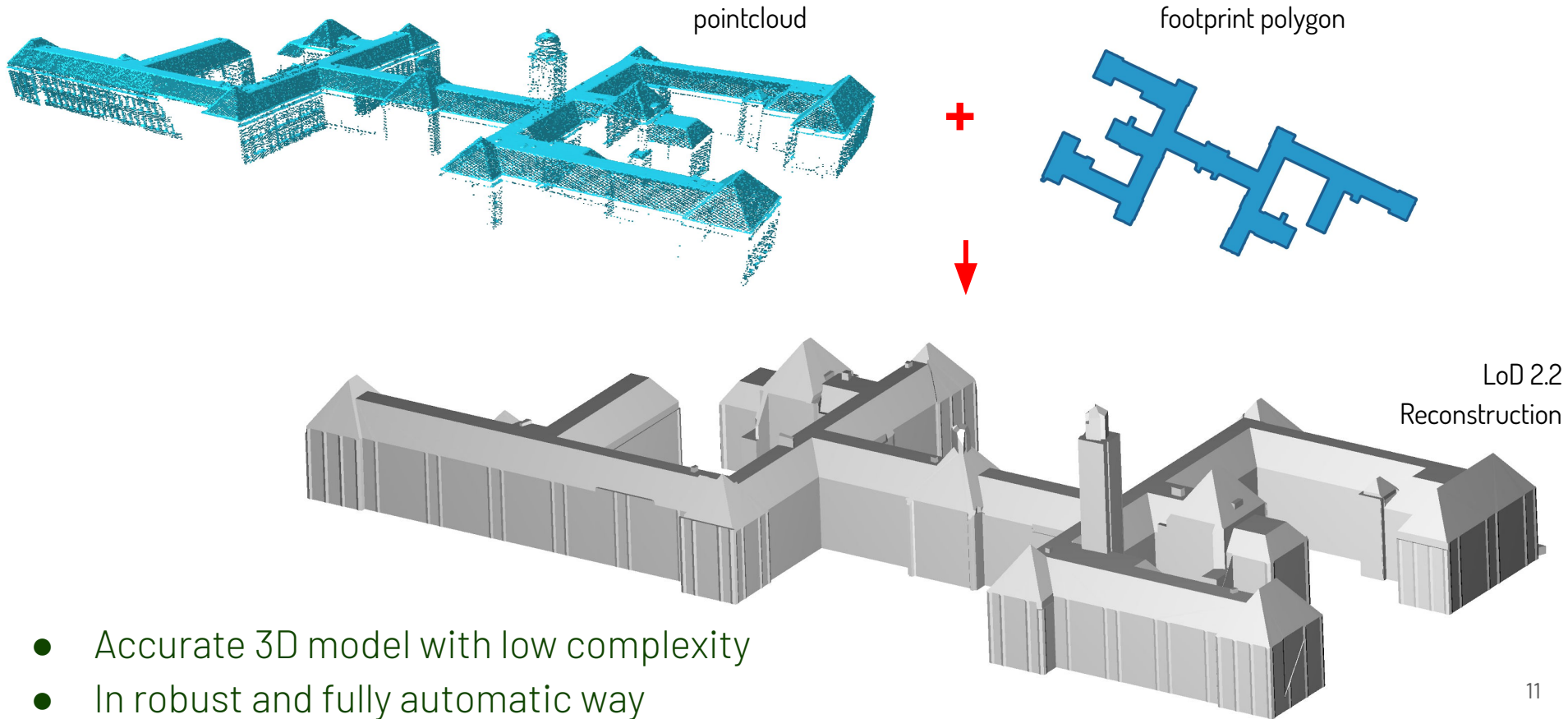
Frank van Gool



Dennis Hulsegge

Reconstruction algorithm

Building reconstruction



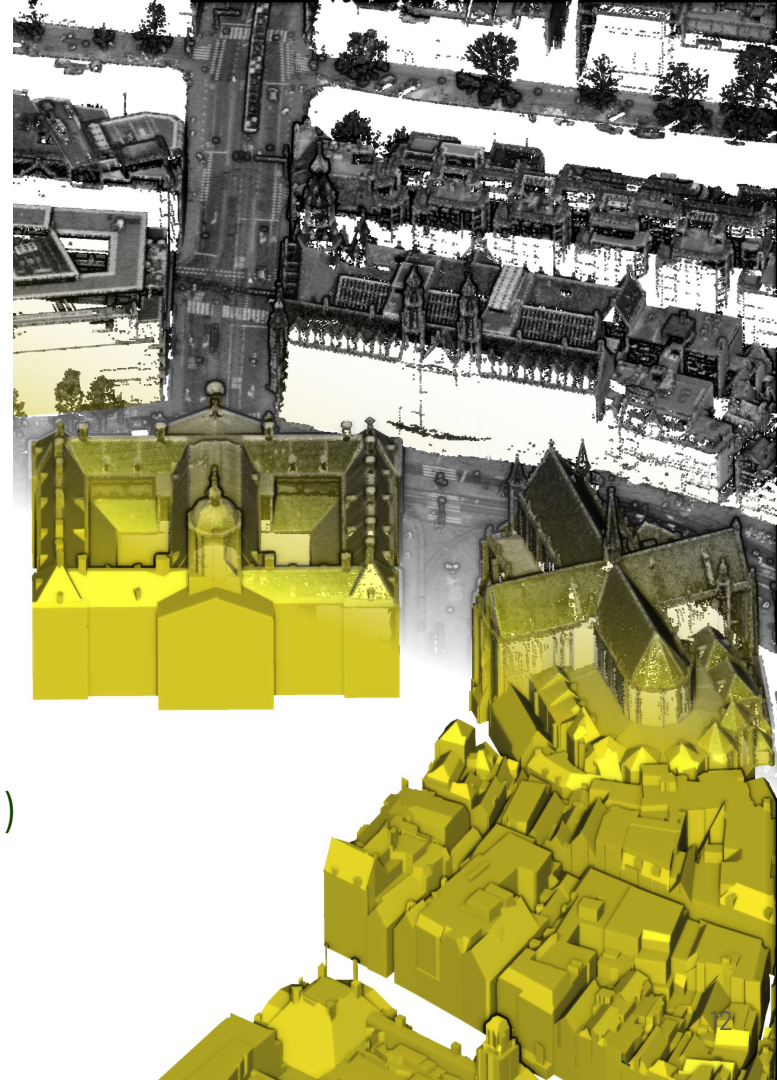
Open data in the Netherlands

BAG <https://www.kadaster.nl/bag>

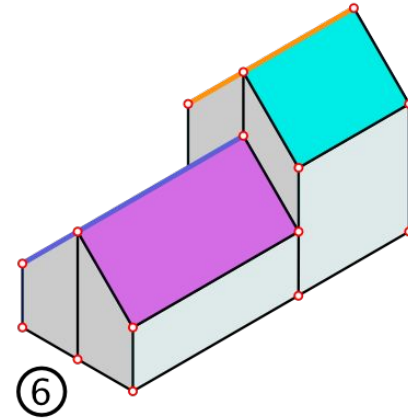
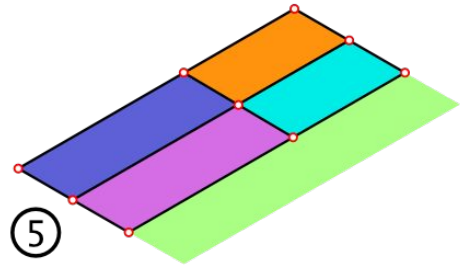
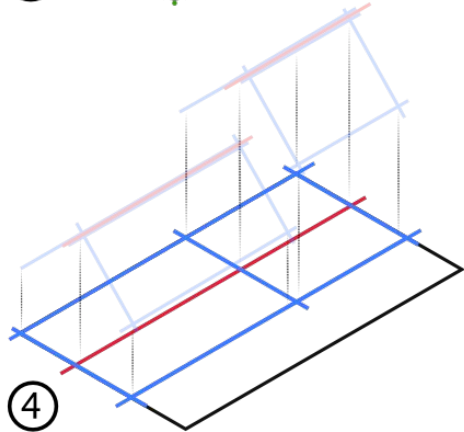
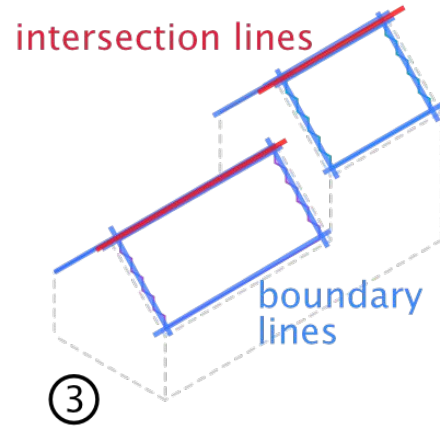
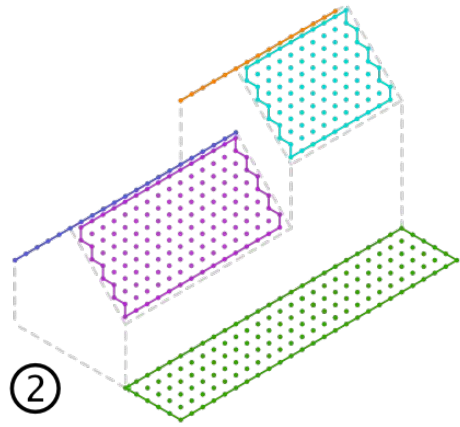
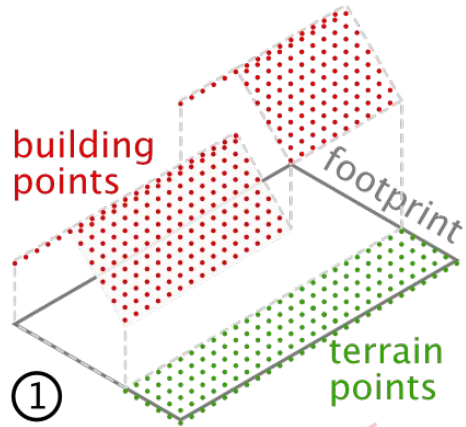
up-to-date building polygons + attributes
largest extent → roofprint + underground
positional accuracy 30cm

AHN <https://ahn.nl>

classified point cloud
positional accuracy ~23cm (height and planimetric)
8-15 pts/m² for buildings
occlusion and other no-data areas

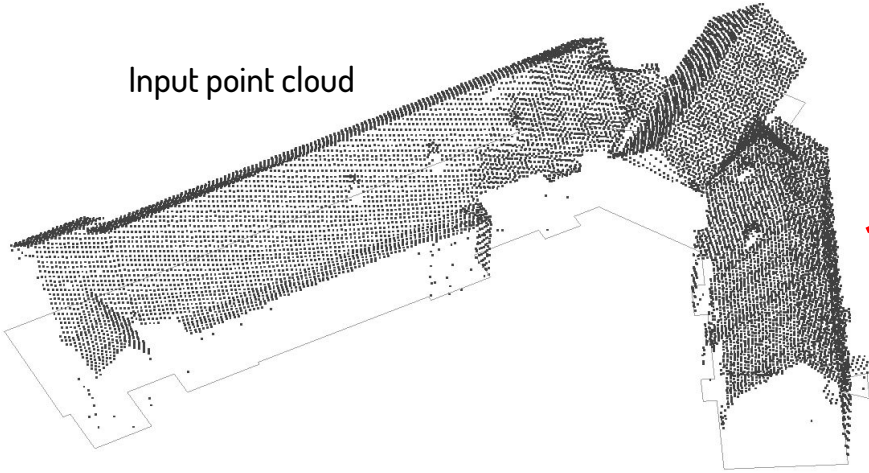


Overview building reconstruction method

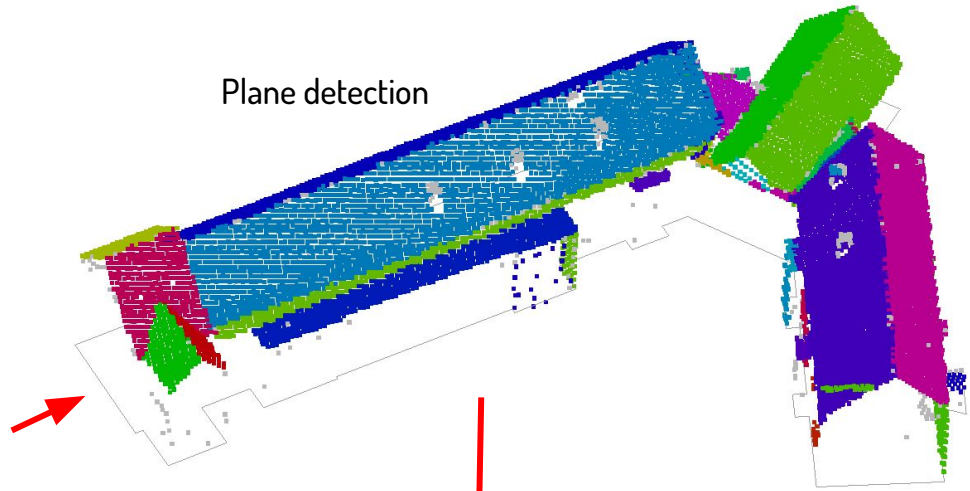


Feature extraction

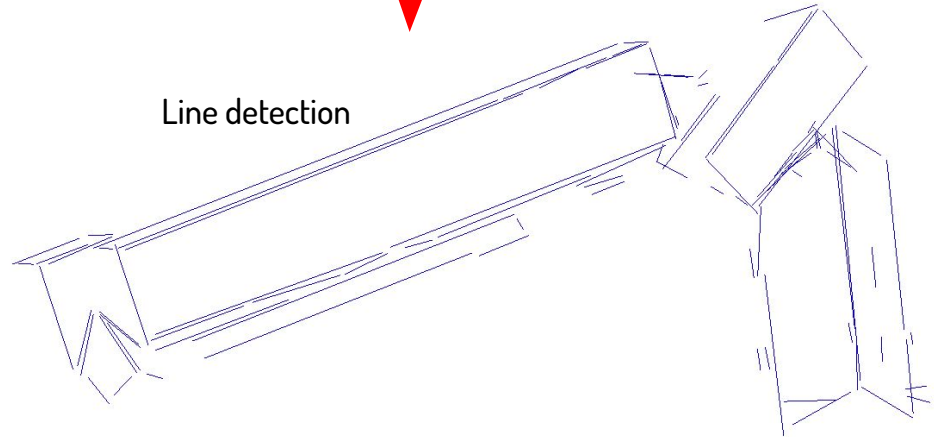
Input point cloud



Plane detection

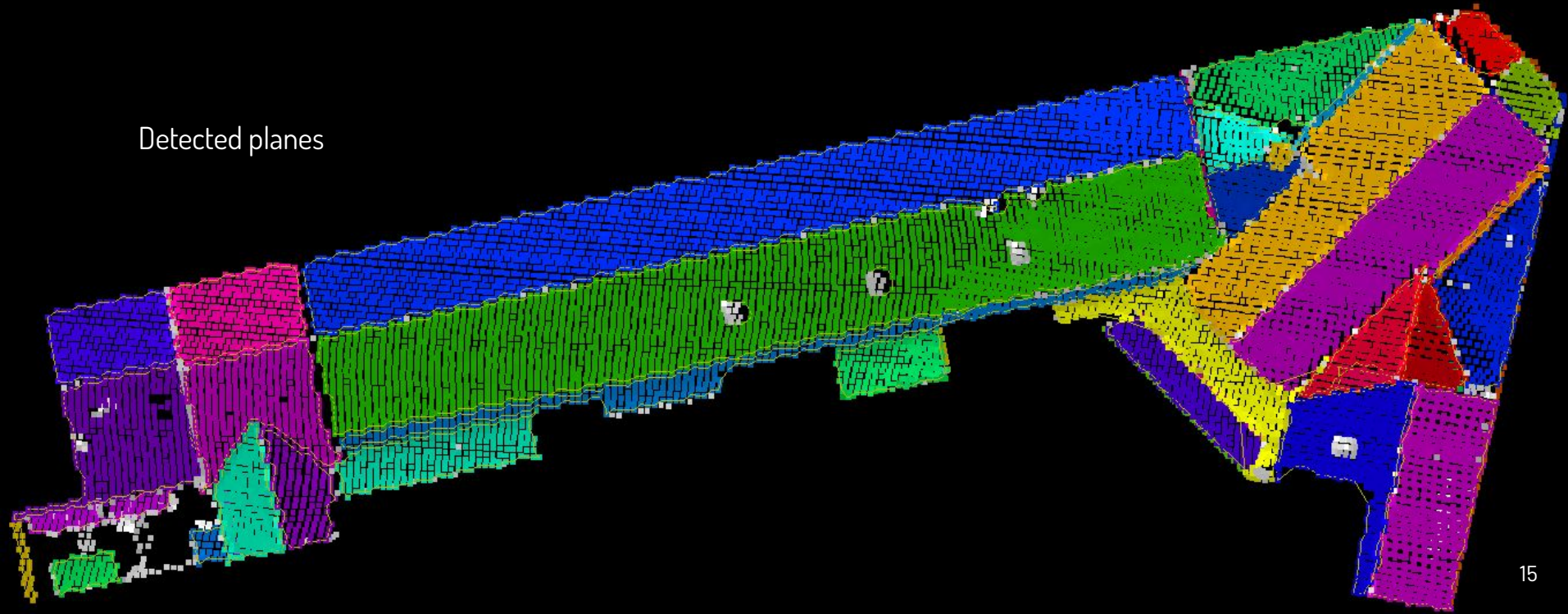


Line detection



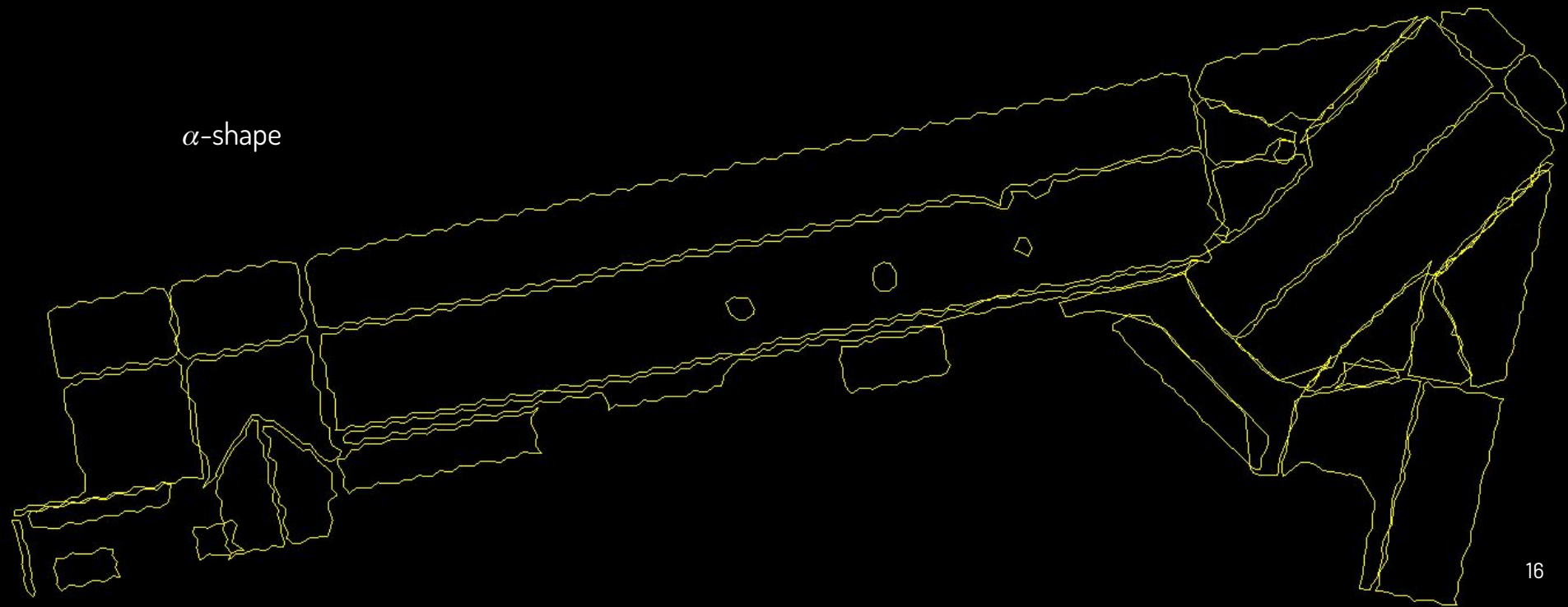
Feature extraction

Detected planes



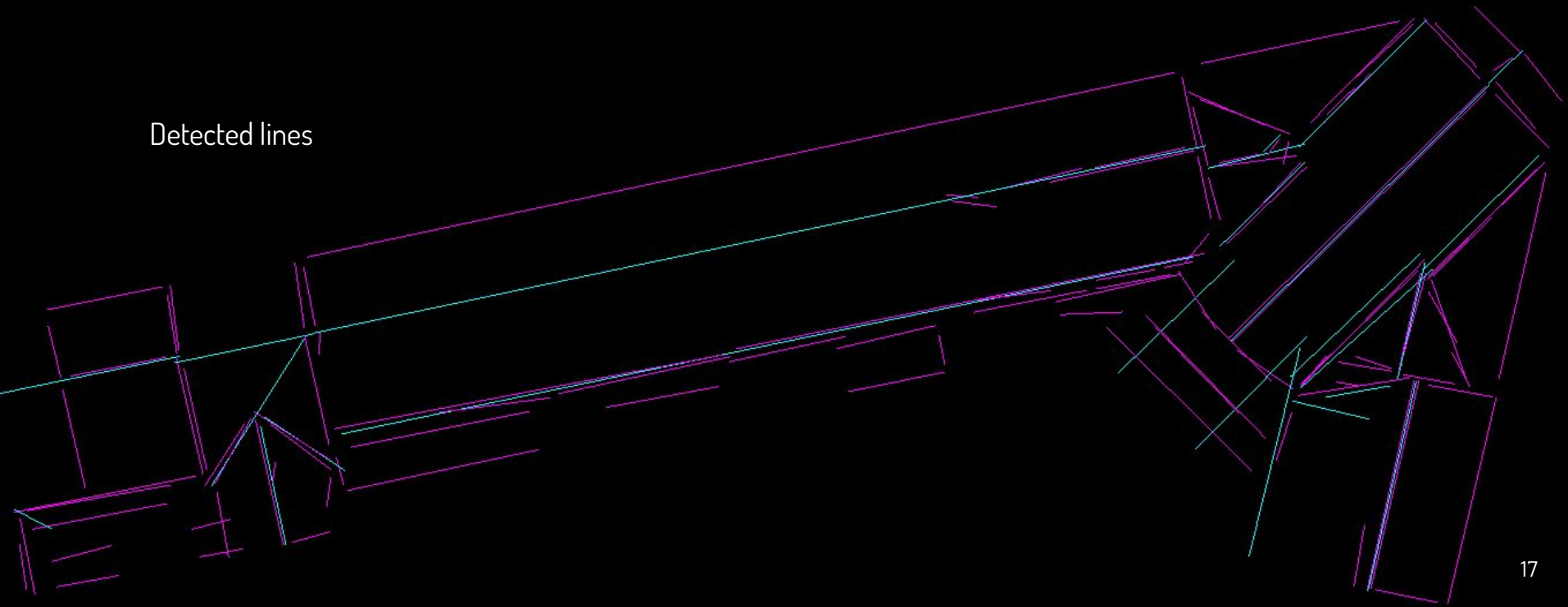
Feature extraction

α -shape



Feature extraction

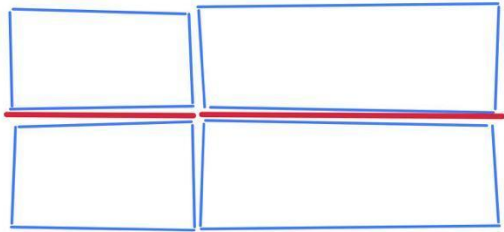
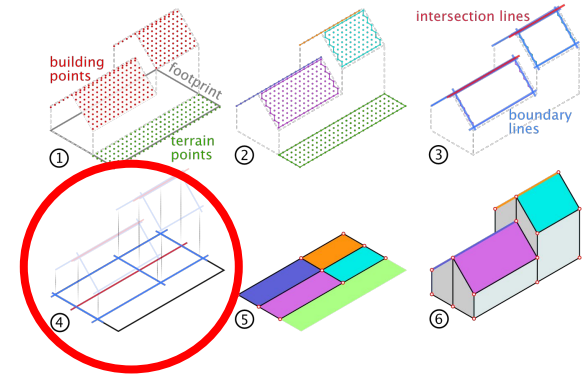
Detected lines



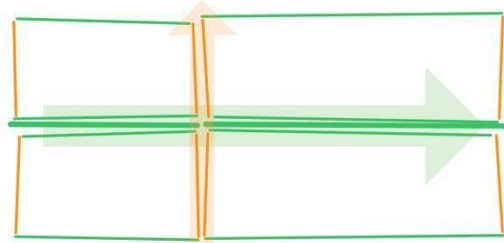
Line regularisation

Using 2-step hierarchical clustering

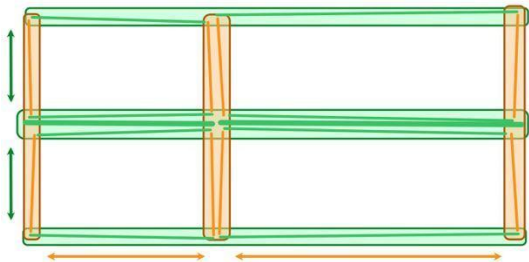
1. Based on line orientation
2. Based on euclidean distance within orientation clusters



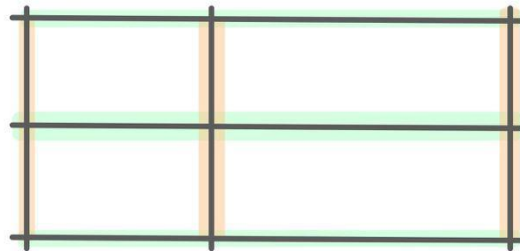
(a) Detected lines



(b) Orientation clustering



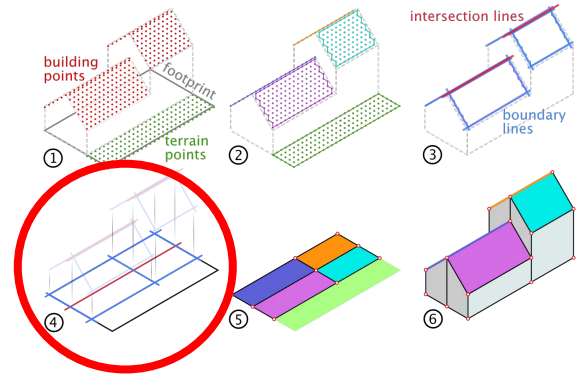
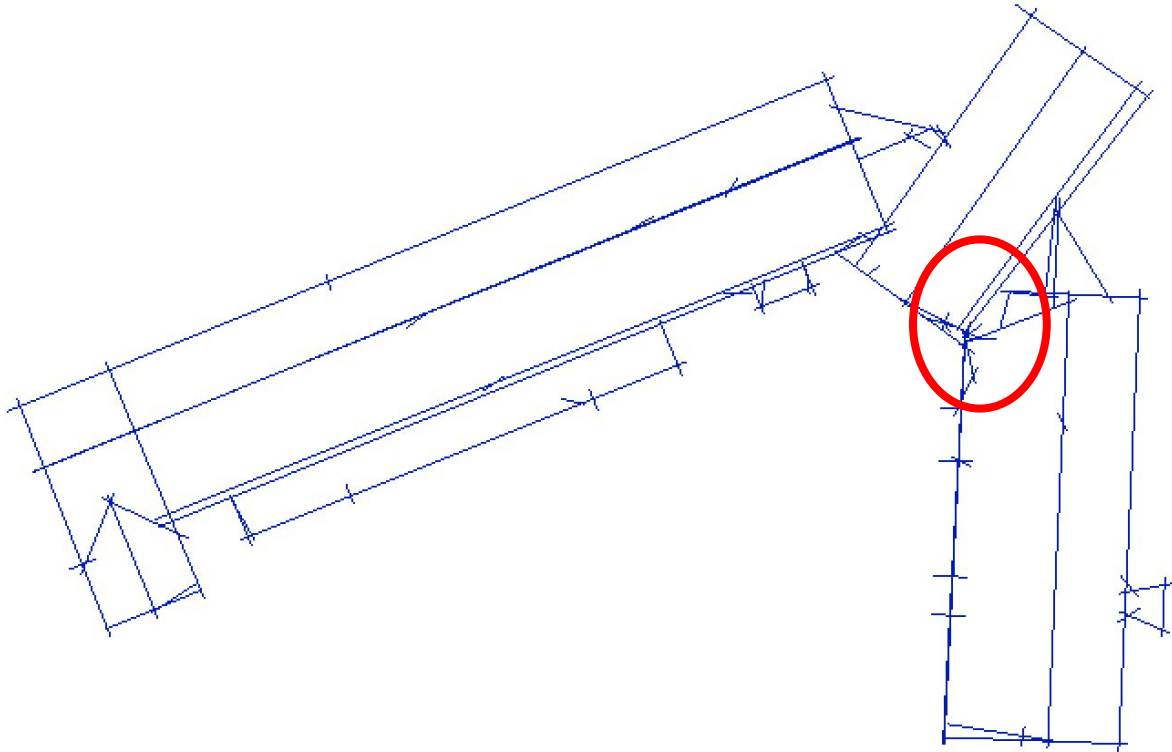
(c) Distance clustering



(d) Regularised lines

Initial roof partition

Still many small faces

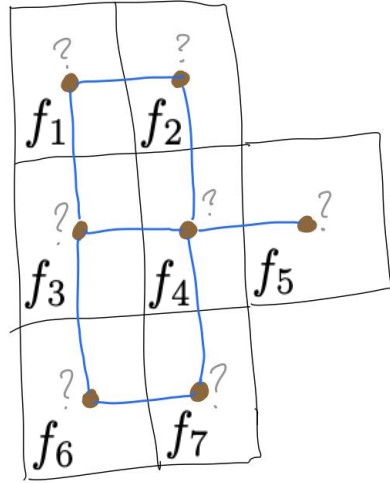


Graph-cut optimisation

[Zebedin et al. \(2008\)](#)

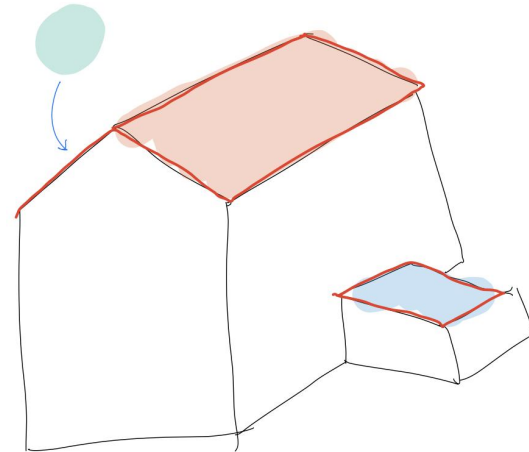
$$E(f) = \lambda \cdot \sum_{p \in P} D_p(f_p) + (1 - \lambda) \cdot \sum_{\{p,q\} \in N} V_{p,q}(f_p, f_q)$$

Dual graph of planar arrangement



possible labels:

1. 
2. 
3. 

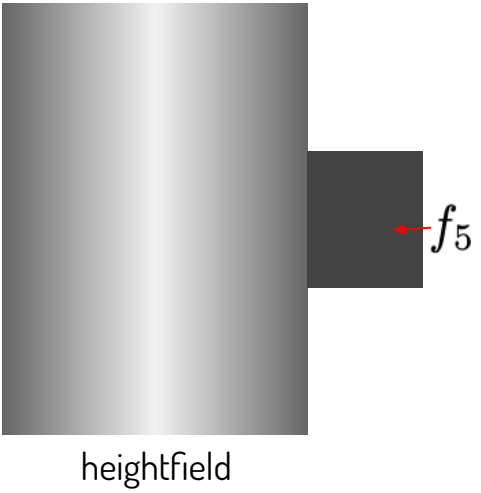


Graph-cut optimisation

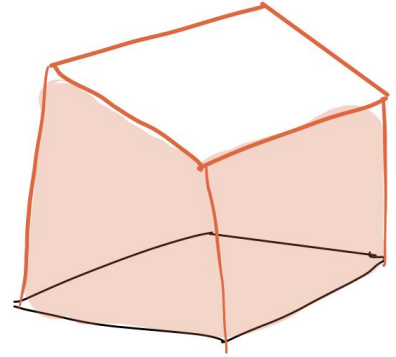
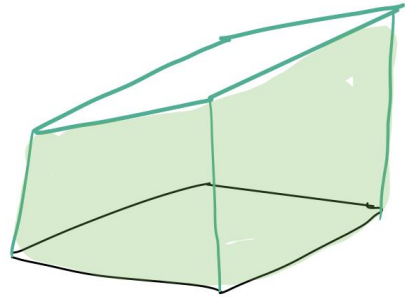
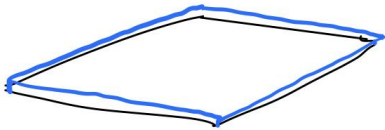
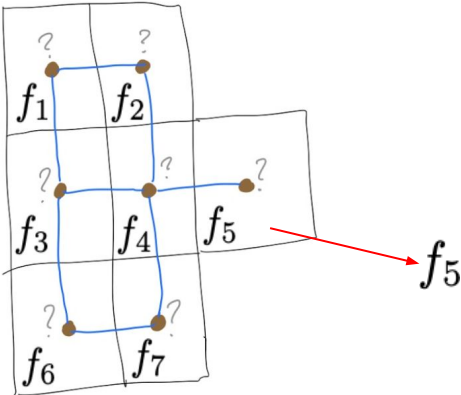
$$E(f) = \lambda \cdot \sum_{p \in P} D_p(f_p) + (1 - \lambda) \cdot \sum_{\{p,q\} \in N} V_{p,q}(f_p, f_q)$$

Data term:

Volume between candidate planes and 2.5D heightfield of point cloud at a face



Maximises data fit



Volume wrt each candidate plane

Graph-cut optimisation

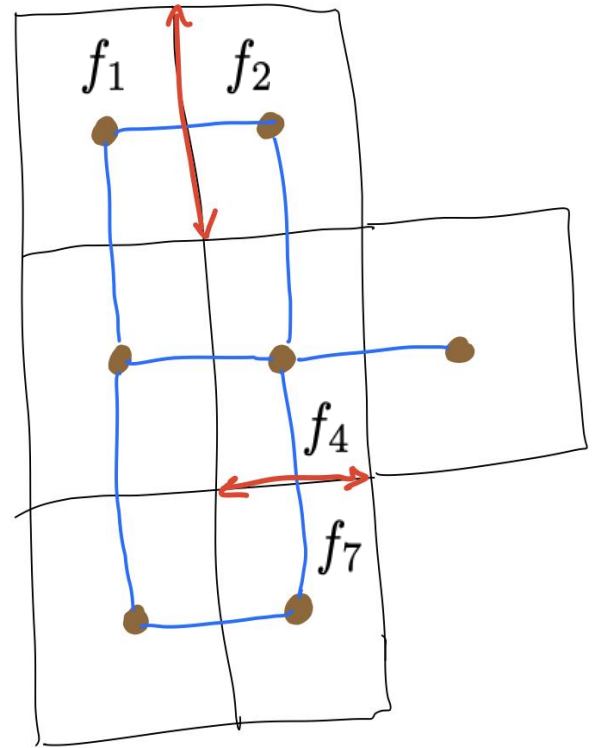
$$E(f) = \lambda \cdot \sum_{p \in P} D_p(f_p) + (1 - \lambda) \cdot \sum_{\{p,q\} \in N} V_{p,q}(f_p, f_q)$$

$$V_{p,q}(f_p, f_q) = \begin{cases} \text{length}(\text{border}(p, q)) & \text{if } f_p \neq f_q \\ 0 & \text{if } f_p = f_q \end{cases}$$

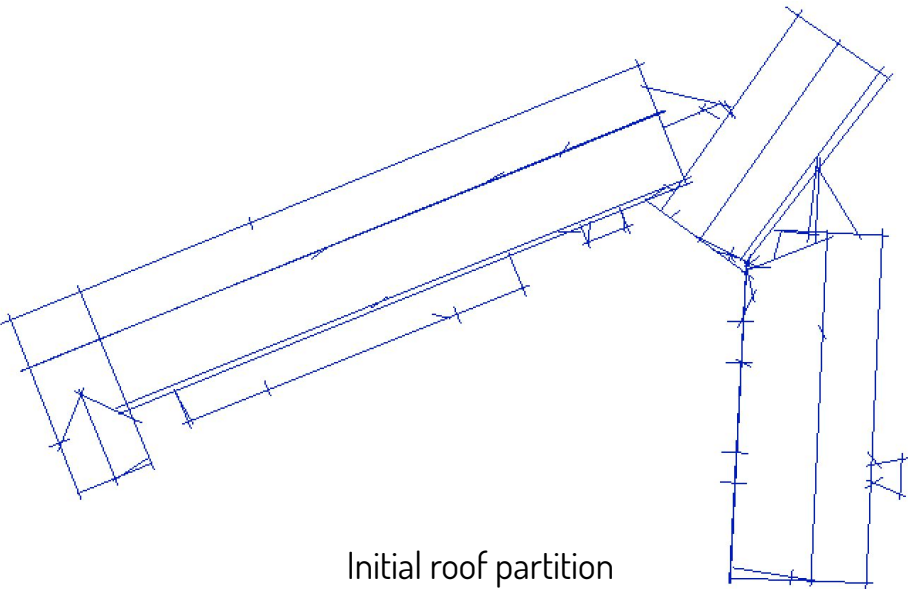
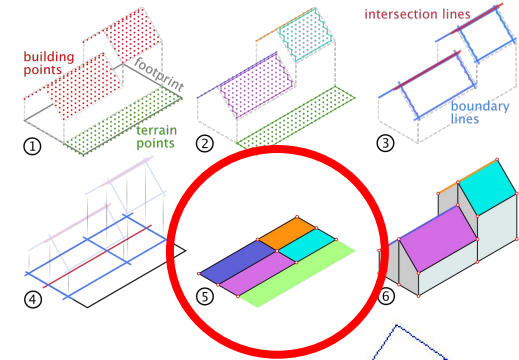
Smoothness term:

Edge length between adjacent faces with unequal plane label

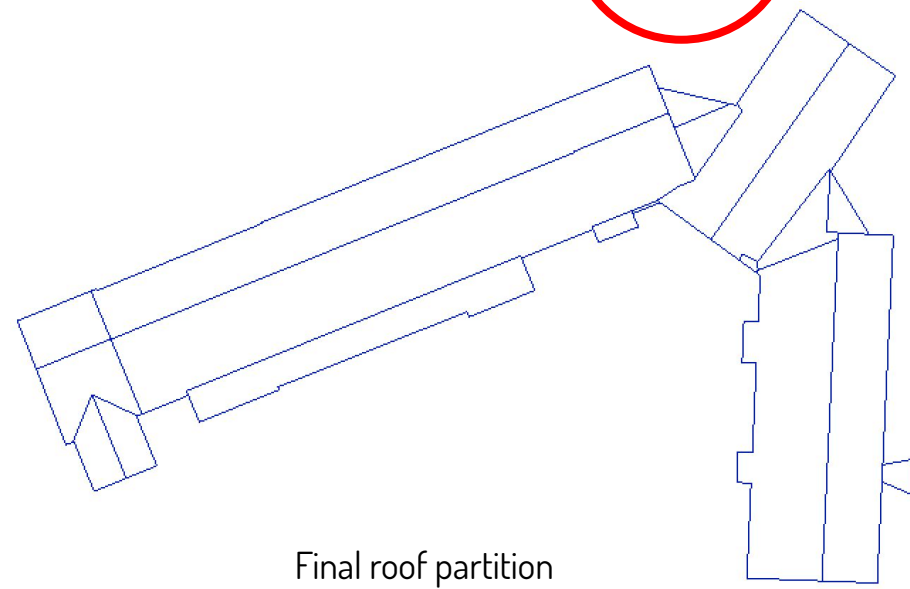
Reduces complexity, discourages height discontinuities



Final roof partition

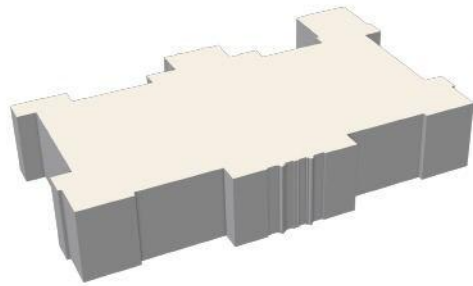


Initial roof partition

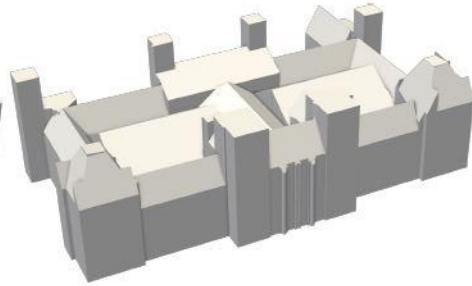


Final roof partition
(edges between equal plane labels dissolved)

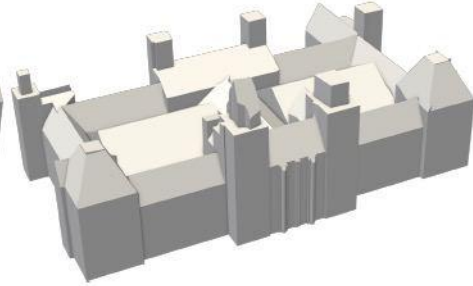
Results: effect of optimisation weights



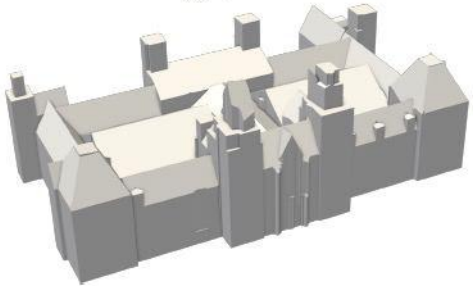
(a) $\lambda = 0.01$



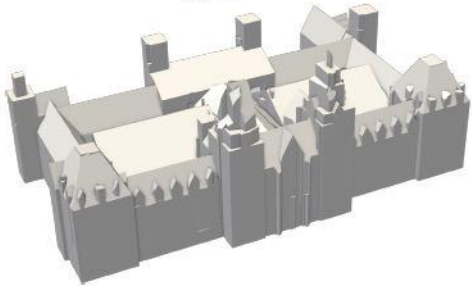
(b) $\lambda = 0.2$



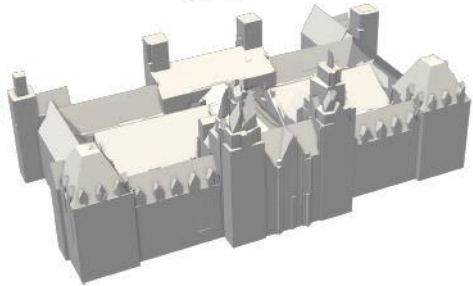
(c) $\lambda = 0.4$



(d) $\lambda = 0.6$



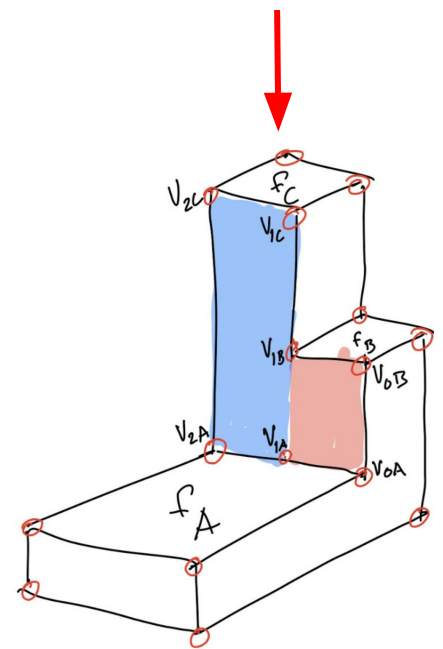
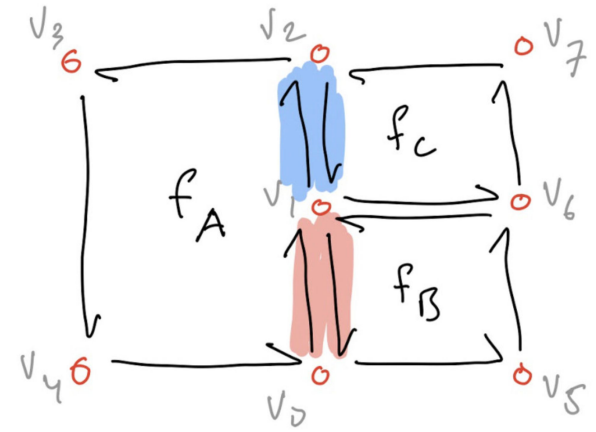
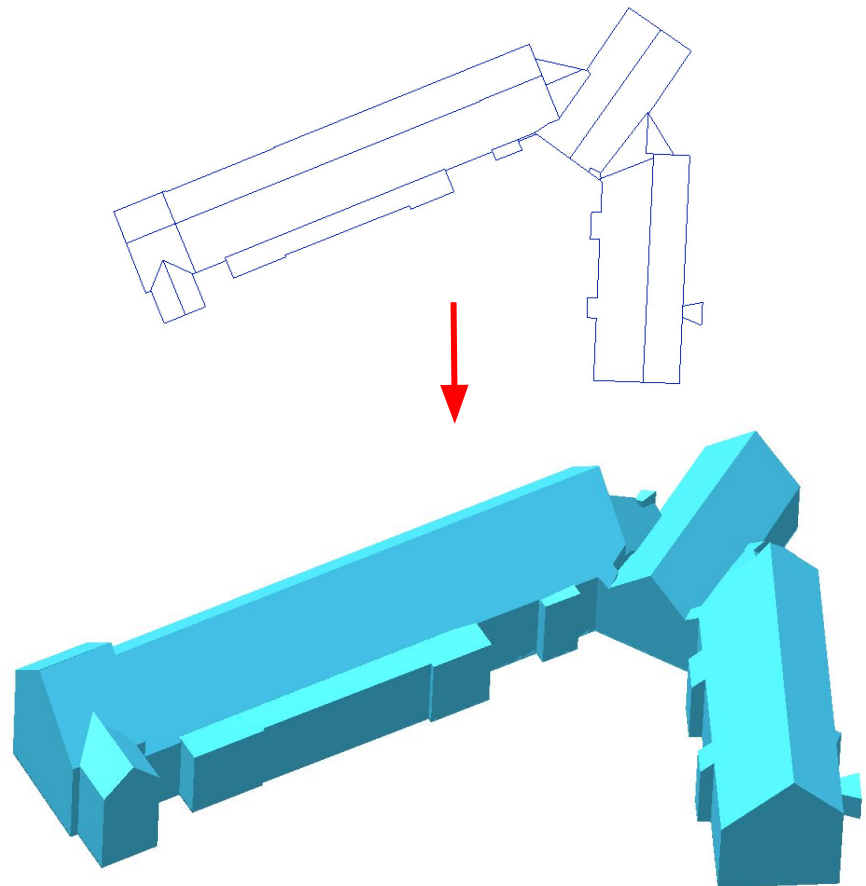
(e) $\lambda = 0.8$



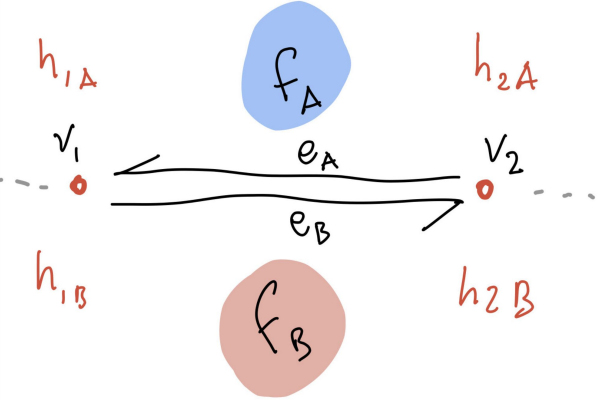
(f) $\lambda = 0.99$

Image by Ivan Pađen

Extrusion



Extrusion



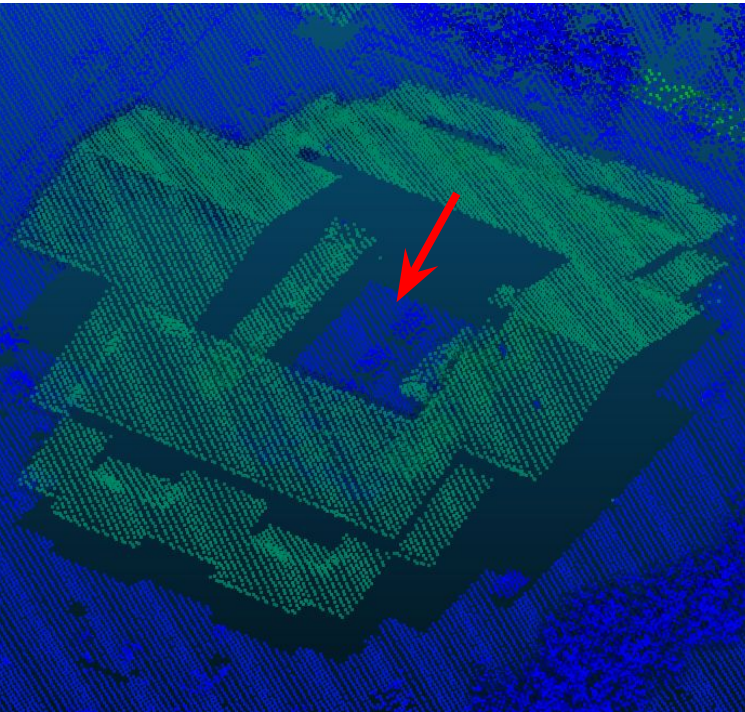
Case	condition	vertex order
	$h_{1A} < h_{1B}$ AND $h_{2A} < h_{2B}$	1. $v_{1B}, v_{1A}, v_{2A}, v_{2B}$
	$h_{1A} < h_{1B}$ AND $h_{2A} > h_{2B}$	1. v_{1B}, v_{1A}, v_x 2. v_{2A}, v_{2B}, v_x } 2 Faces!
	$h_{1A} < h_{1B}$ AND $h_{2A} = h_{2B}$	1. v_{1B}, v_{1A}, v_{2A}

Special cases, Limitations

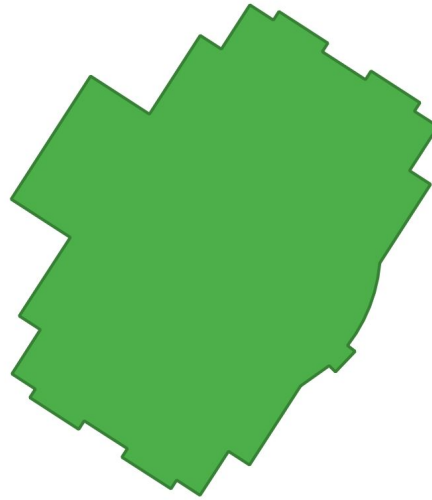
Groundparts

In some cases BAG footprint includes groundparts

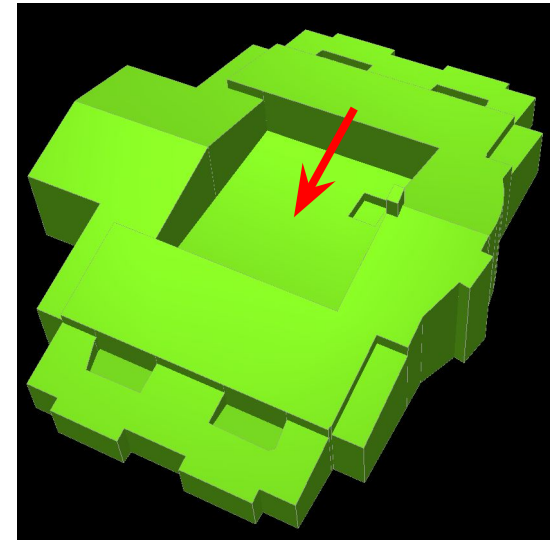
AHN3 ground and building class



BAG footprint



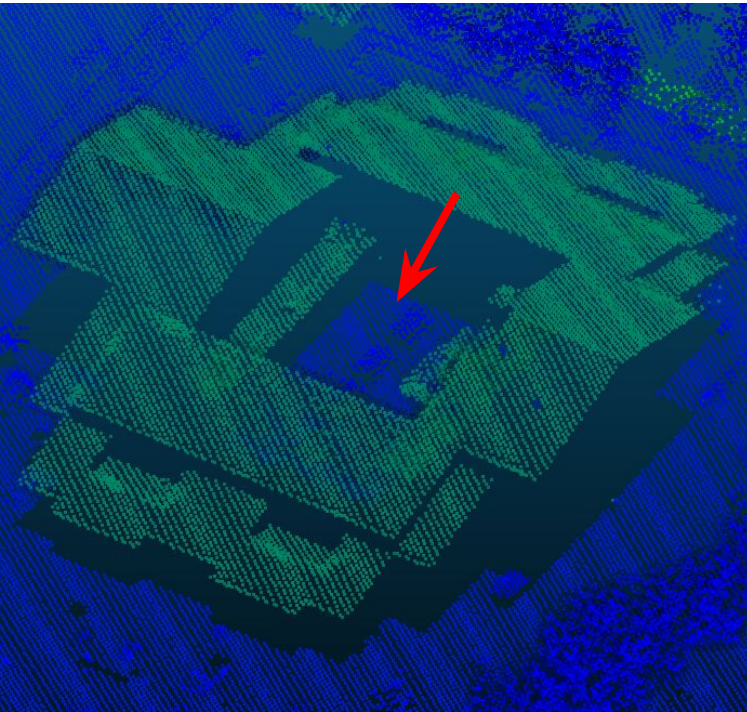
Reconstruction result:
roofplane fitted to groundpart



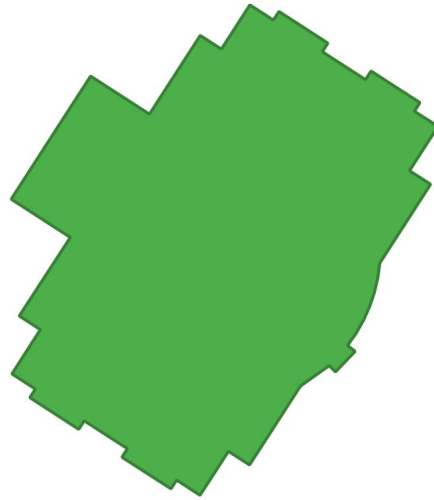
Groundparts

Reconstruction with groundpart detection

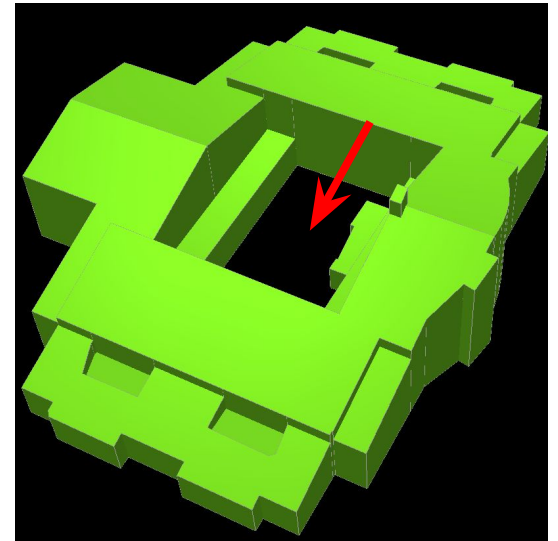
AHN3 ground and building class



BAG footprint

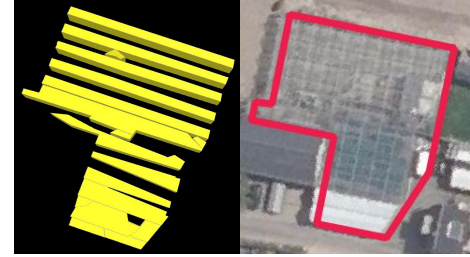


Reconstruction result:
groundpart removed from output



Limitation: glass roofs

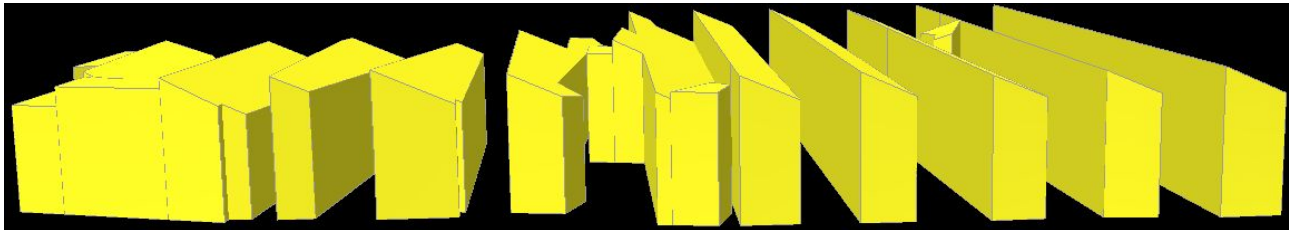
Green houses: both points on ground and on roof



AHN3
ground and building class



Heightfield

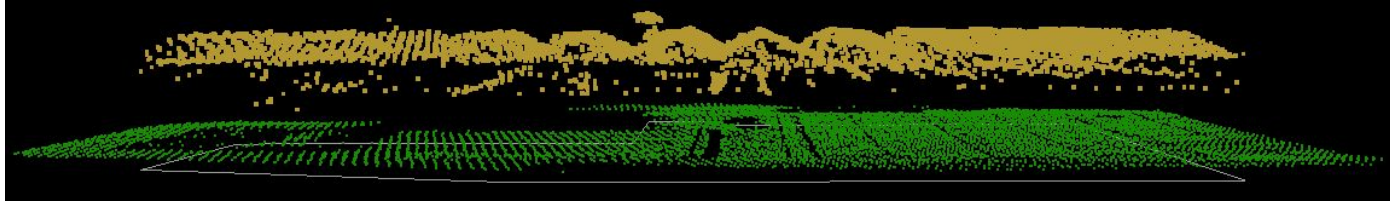


Reconstruction result

Limitation: glass roofs

Green houses: both points on ground and on roof

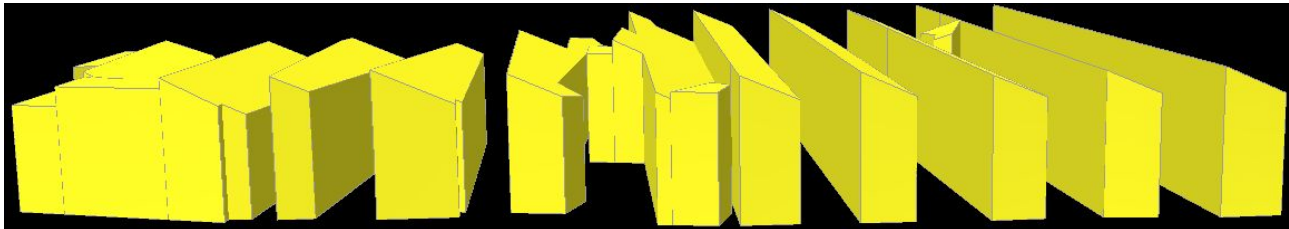
Current solution:
Use greenhouse classification from
TOP10NL, reconstruct as LoD 1.2



AHN3
ground and building class



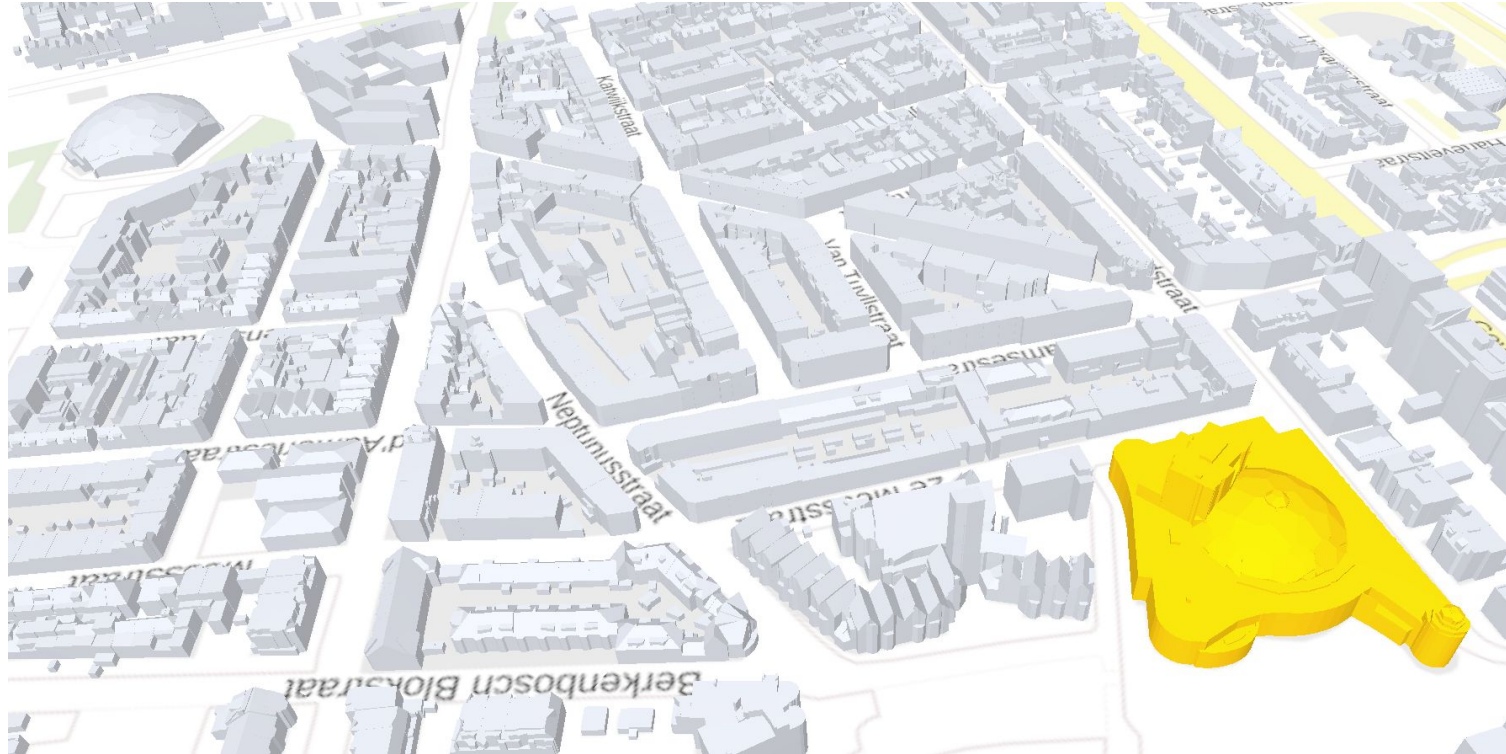
Heightfield



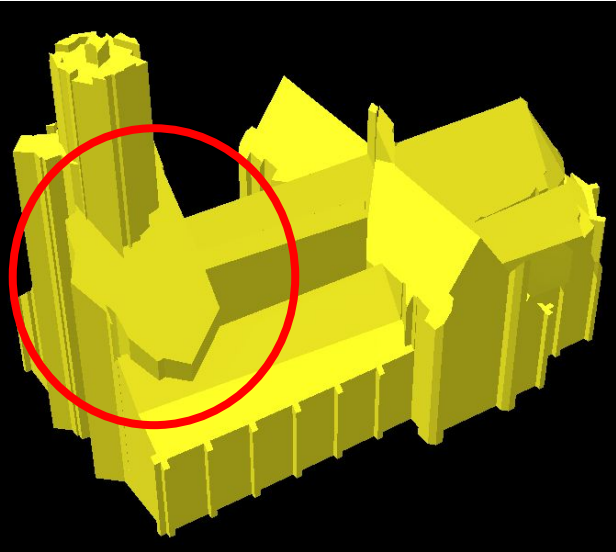
Reconstruction result

Spherical surfaces

Are approximated with planar surfaces if sufficient point density

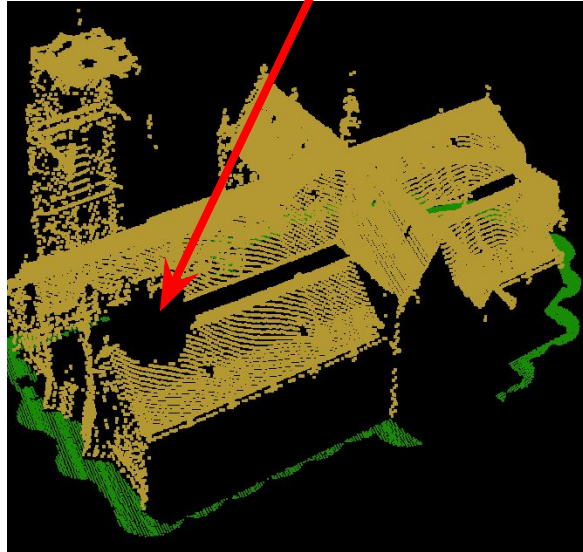


Limitations: occlusion/no-data



Reconstruction

Occlusion/no-data

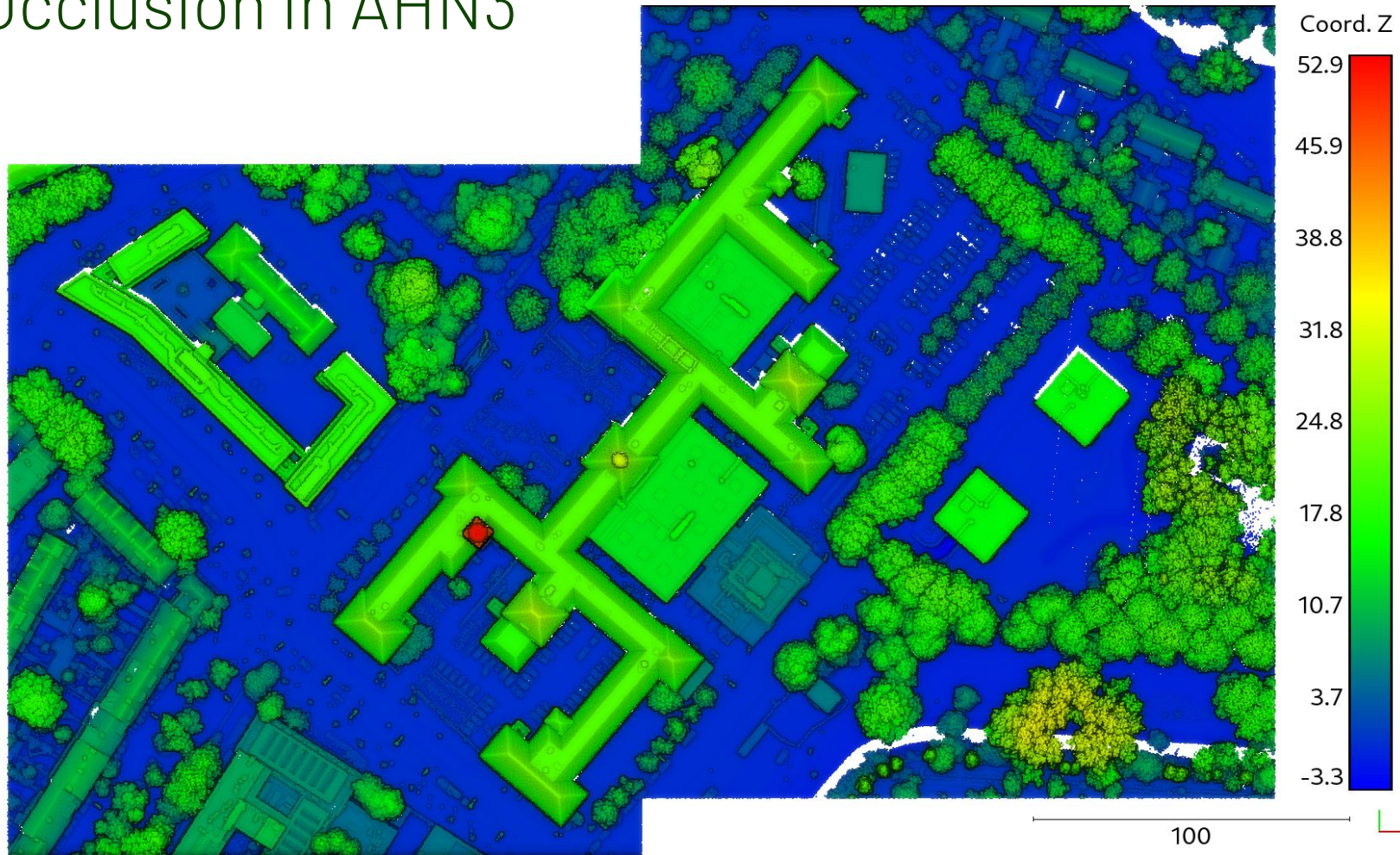


AHN3 ground and building class

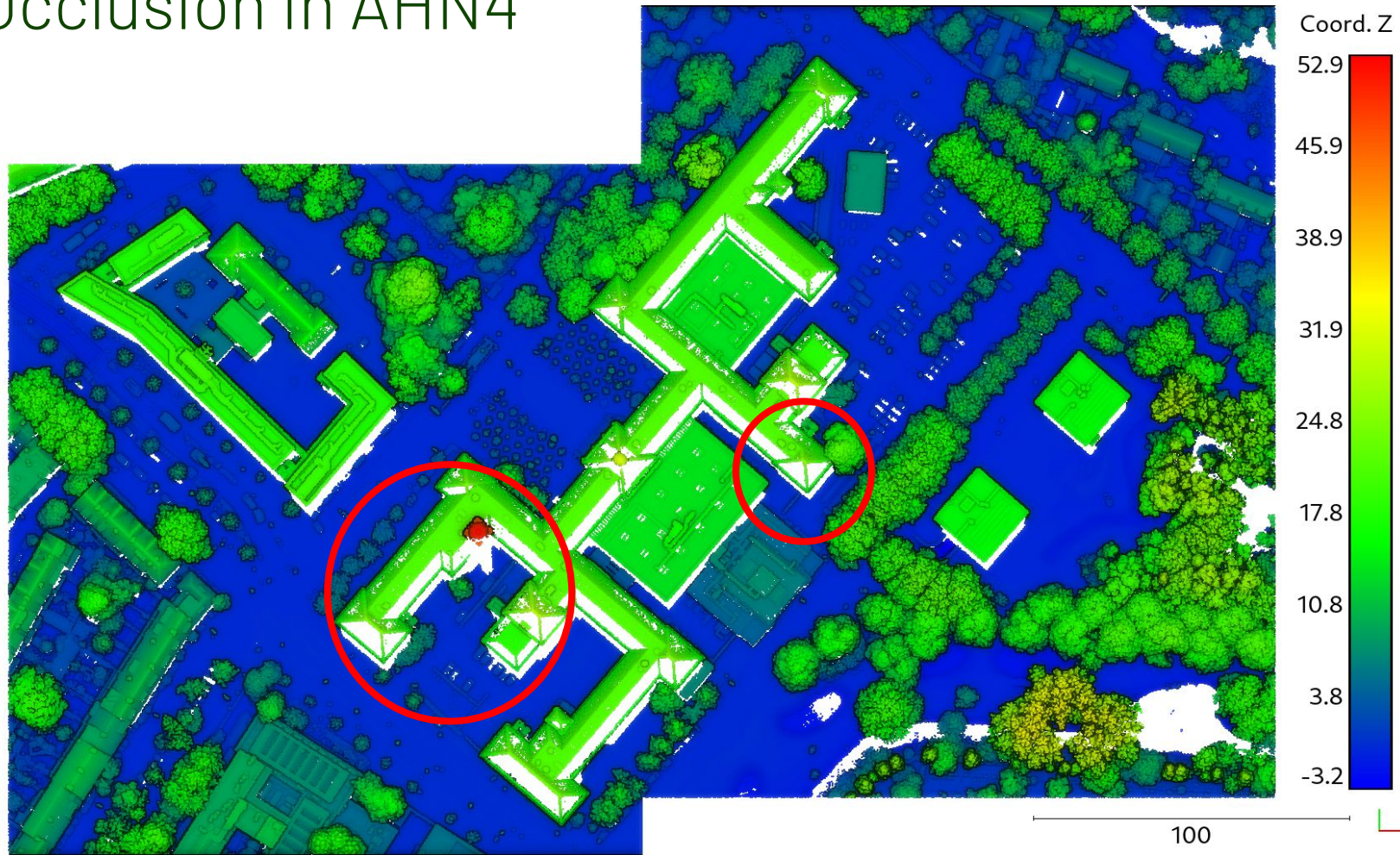


Heightfield

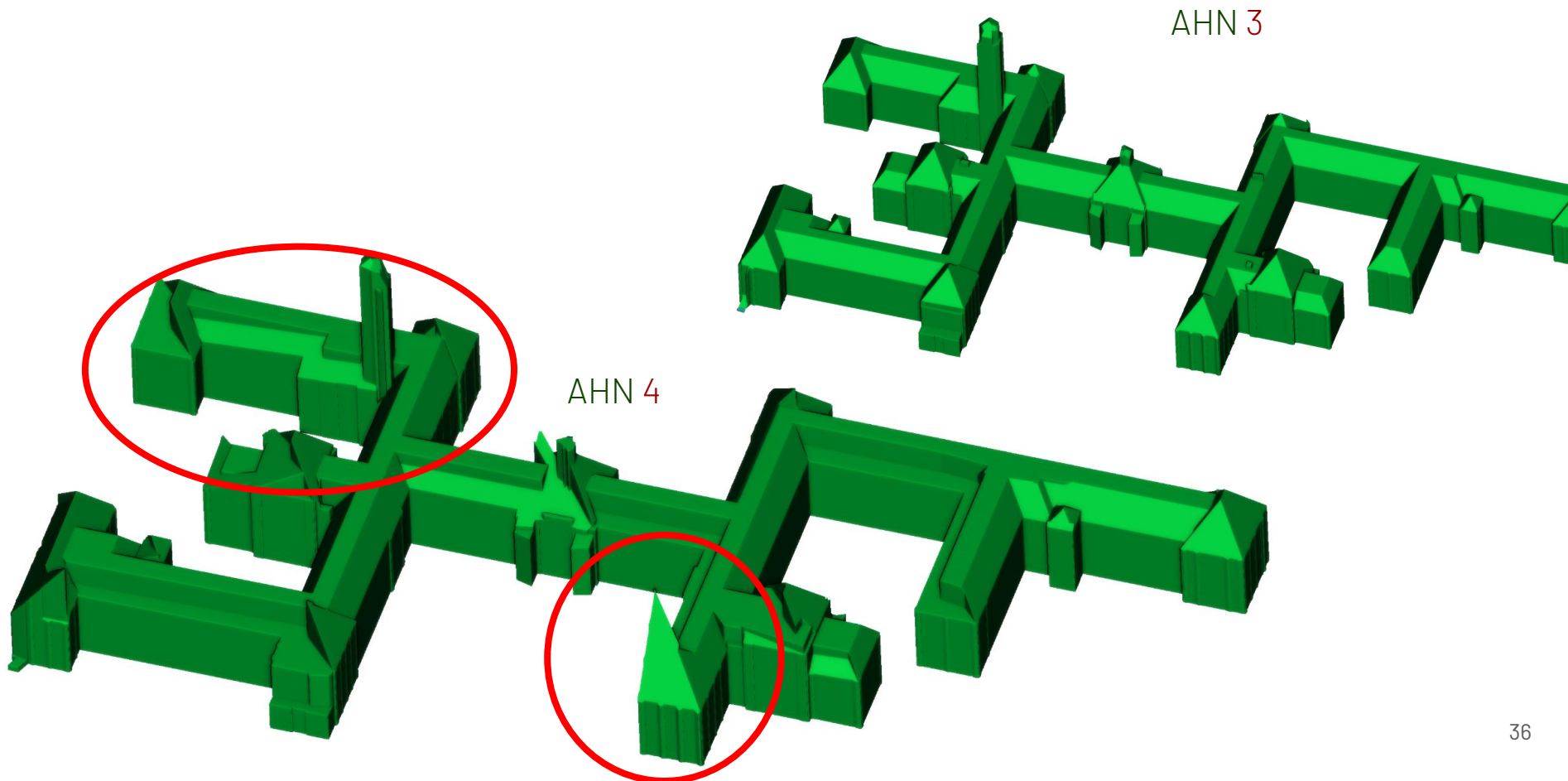
Occlusion in AHN3



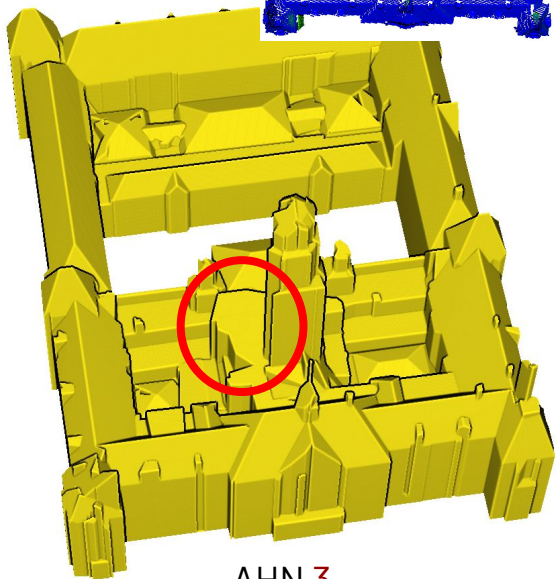
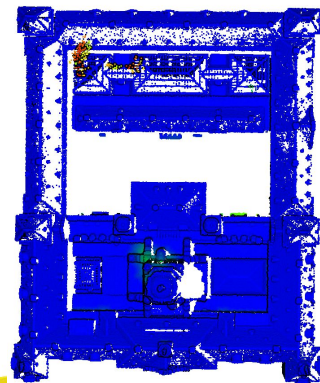
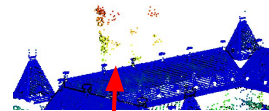
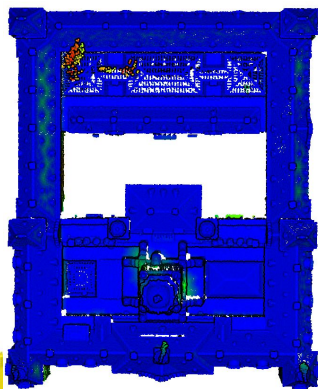
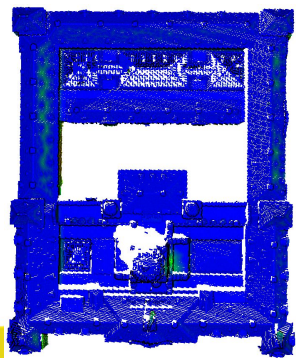
Occlusion in AHN4



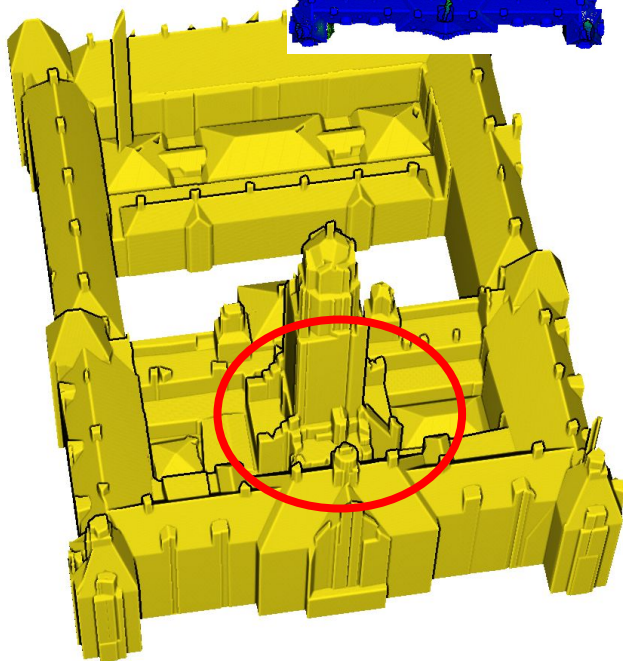
Occlusion effect on reconstruction



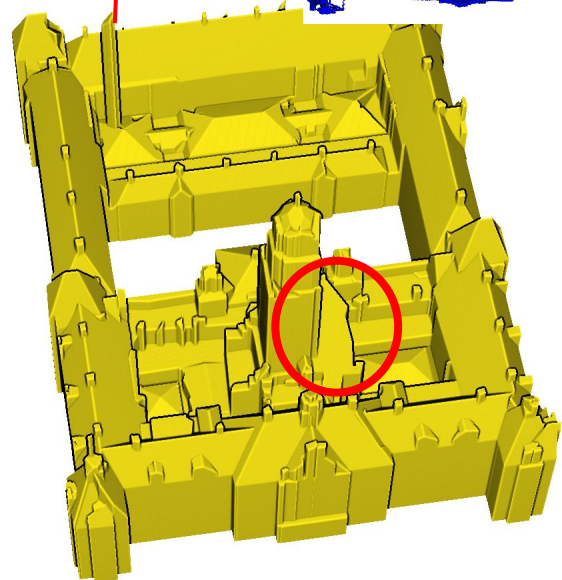
Fuse two point clouds



AHN 3



AHN 3+4

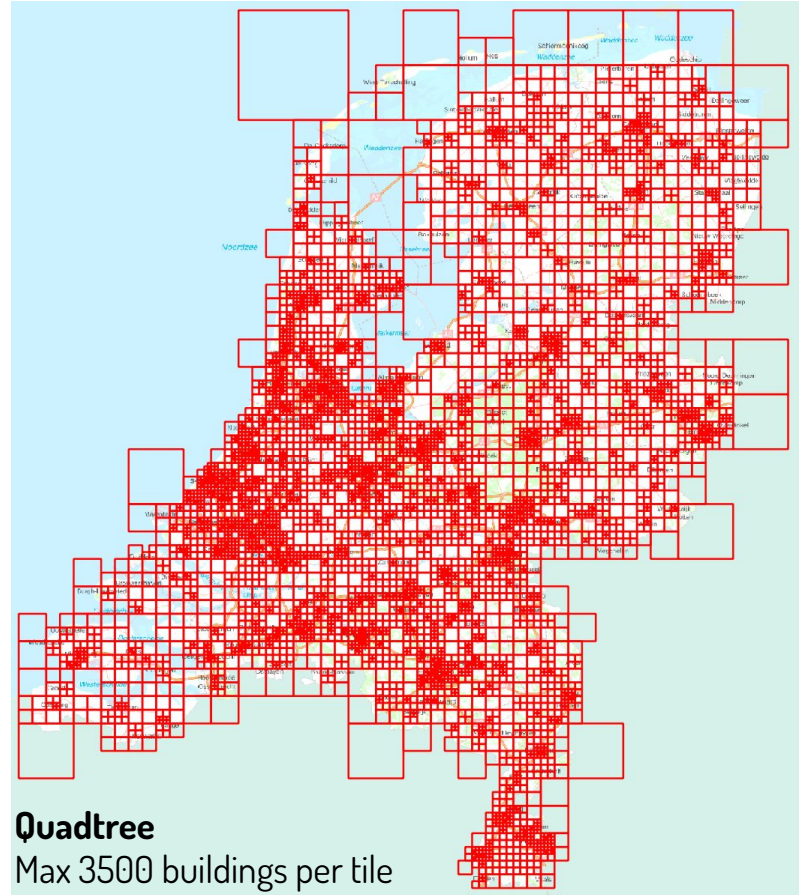
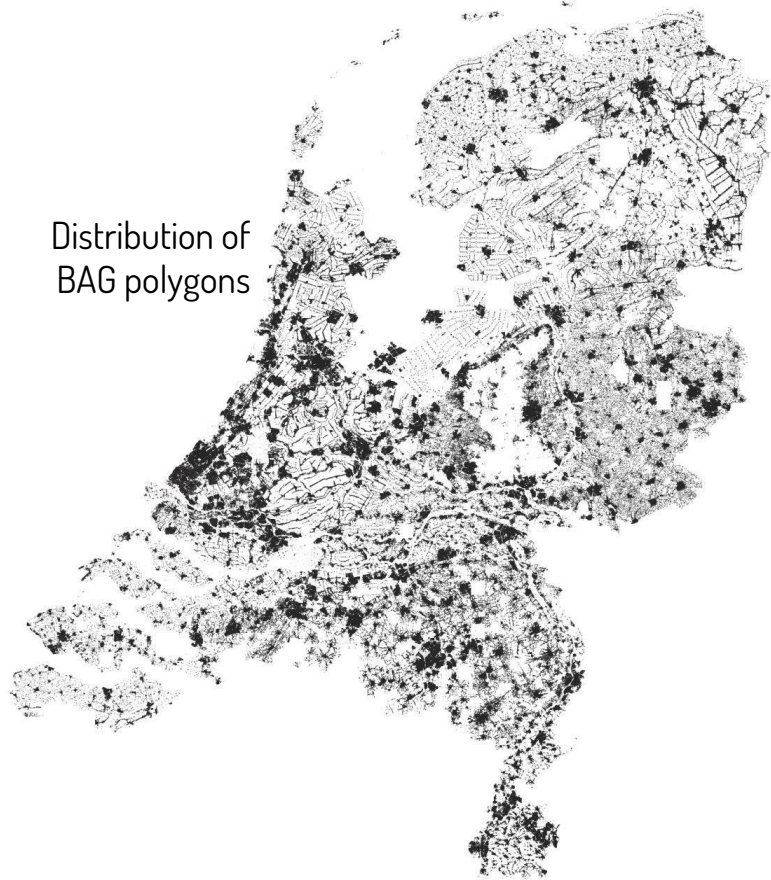


AHN 4

Data management

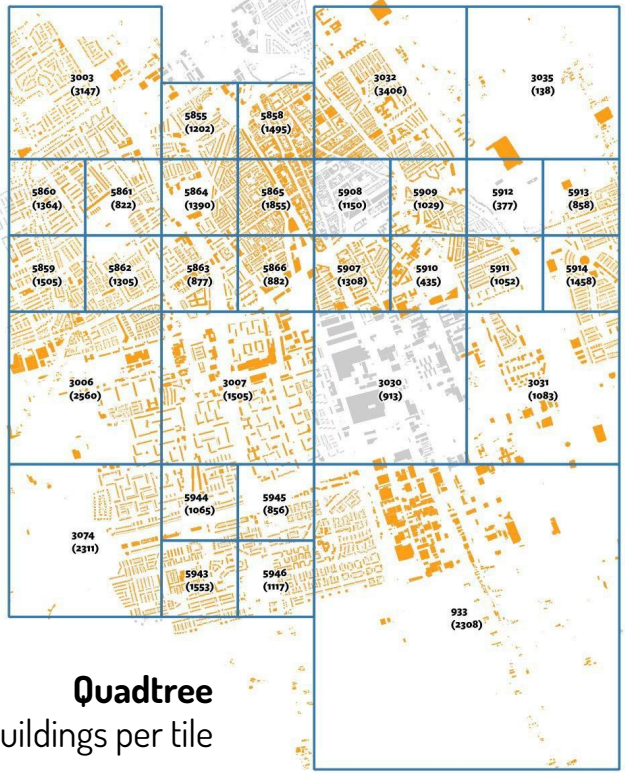
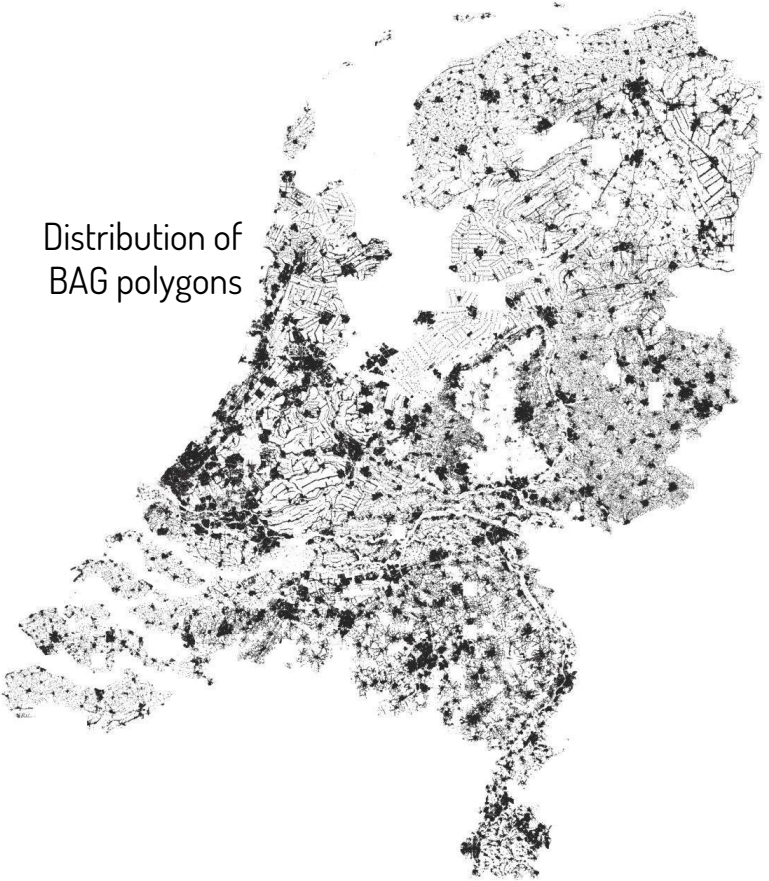
How to tile the data?

Distribution of
BAG polygons



How to tile the data?

Distribution of BAG polygons



Quadtree
Max 3500 buildings per tile

Data distribution

Tiles

- GeoPackage
- CityJSON
- OBJ (triangulated)

Webservices

- WFS/WMS
- 3DBAG API
(OGC API CityJSON Features)

Downloads for tile number 9-280-556

To keep file sizes manageable the 3DBAG dataset is subdivided in tiles. For each tile we offer the data in a number of different file formats. Use the button below to select the tile of interest to see the download options.

Tile number	Format	File	SHA-256	Version
9-280-556	CityJSON ?	9-280-556.city.json	See tiles layer in WFS	v2024.02.28
9-280-556	OBJ ?	9-280-556-obj.zip	See tiles layer in WFS	v2024.02.28
9-280-556	GPKG ?	9-280-556.gpkg	See tiles layer in WFS	v2024.02.28

Webservices

These allow you to explore the entire dataset in another software (eg. QGIS) without having to download anything beforehand. Note that only the 2D projection of the models is served via WMS/WFS.

Type	URL
WMS ?	https://data.3dbag.nl/api/BAG3D/wms?request=getcapabilities
WFS ?	https://data.3dbag.nl/api/BAG3D/wfs?request=getcapabilities
3D API (experimental) ?	https://api.3dbag.nl/

Recently added features

3DBAG API

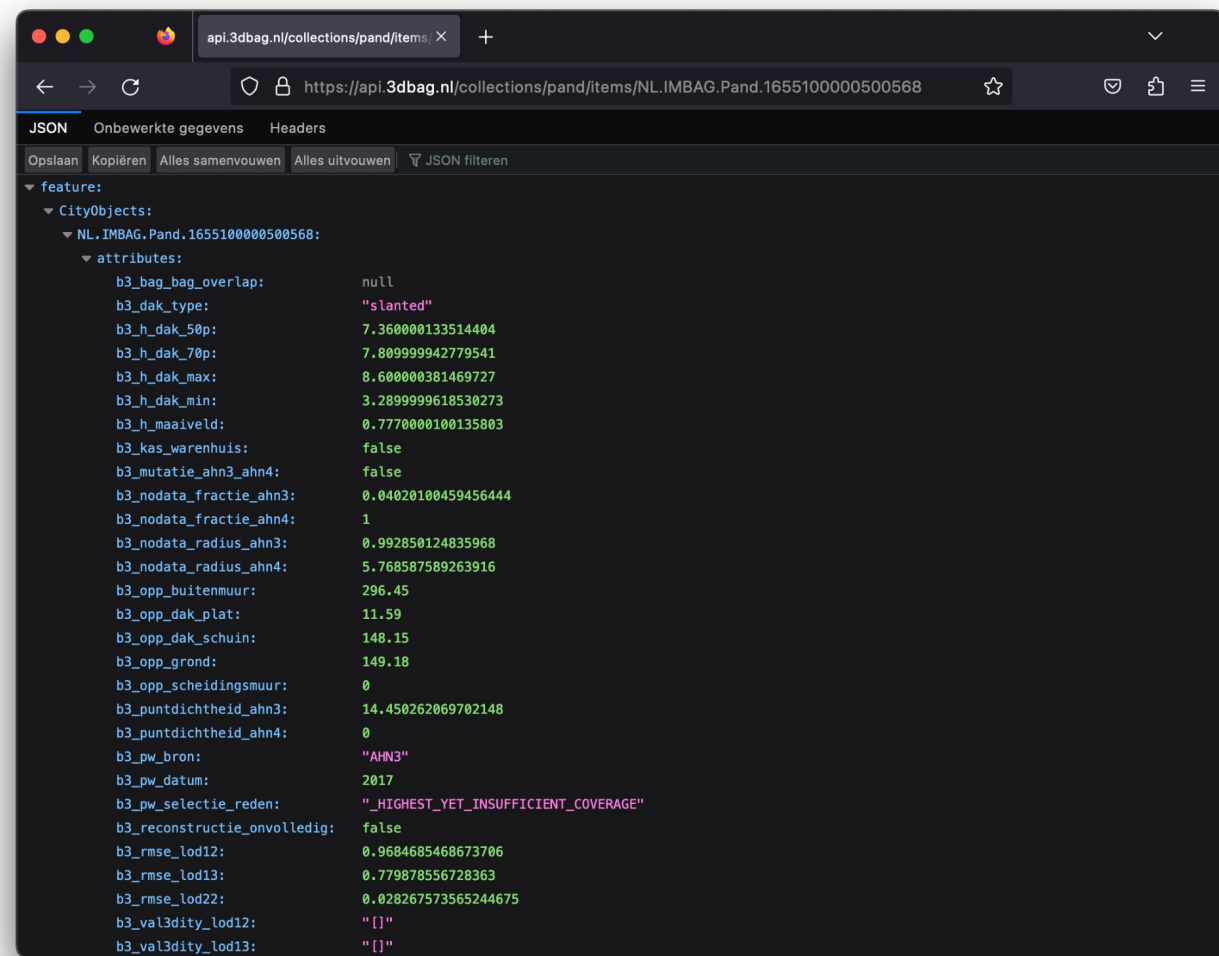
Request directly CityJSON

Features by

- Building ID
- Bounding box

Based on [CJDB](#)

(2022 geomatics synthesis project)



```
api.3dbag.nl/collections/pand/items × +
https://api.3dbag.nl/collections/pand/items/NL.IMBAG.Pand.1655100000500568
JSON Onbewerkte gegevens Headers
Opslaan Kopiëren Alles samenvouwen Alles uitvouwen JSON filteren
feature:
  CityObjects:
    NL.IMBAG.Pand.1655100000500568:
      attributes:
        b3_bag_bag_overlap: null
        b3_dak_type: "slanted"
        b3_h_dak_50p: 7.360000133514404
        b3_h_dak_70p: 7.809999942779541
        b3_h_dak_max: 8.600000381469727
        b3_h_dak_min: 3.2899999618530273
        b3_h_maaiveld: 0.7770000100135803
        b3_kas_warenhuis: false
        b3_mutatie_ahn3_ahn4: false
        b3_nodata_fractie_ahn3: 0.04020100459456444
        b3_nodata_fractie_ahn4: 1
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        b3_nodata_radius_ahn4: 5.768587589263916
        b3_opp_buitenmuur: 296.45
        b3_opp_dak_plat: 11.59
        b3_opp_dak_schuin: 148.15
        b3_opp_grond: 149.18
        b3_opp_scheidingsmuur: 0
        b3_punt dichtheid_ahn3: 14.450262069702148
        b3_punt dichtheid_ahn4: 0
        b3_pw_bron: "AHN3"
        b3_pw_datum: 2017
        b3_pw_selectie_reden: "_HIGHEST_YET_INSUFFICIENT_COVERAGE"
        b3_reconstructie_onvolledig: false
        b3_rmse_lod12: 0.9684685468673706
        b3_rmse_lod13: 0.779878556728363
        b3_rmse_lod22: 0.028267573565244675
        b3_val3dity_lod12: "[]"
        b3_val3dity_lod13: "[]"
```

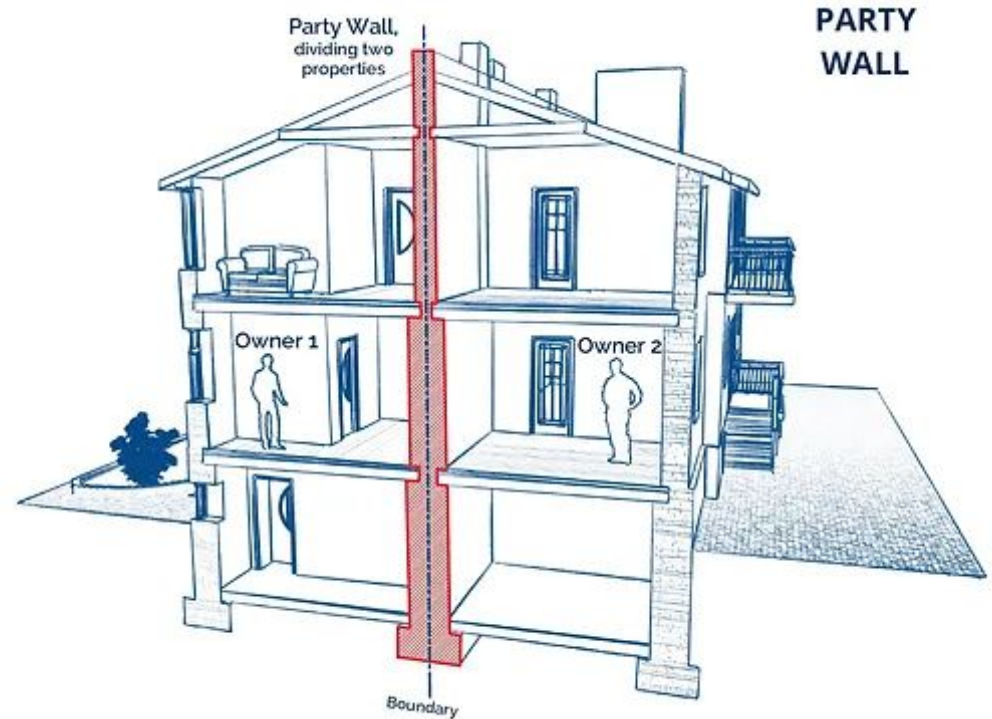
Party wall areas

We calculate and include:

- area party walls
- area exterior walls
- area floor surfaces
- area roof surfaces
- building volume

Needed for eg. energy label estimation

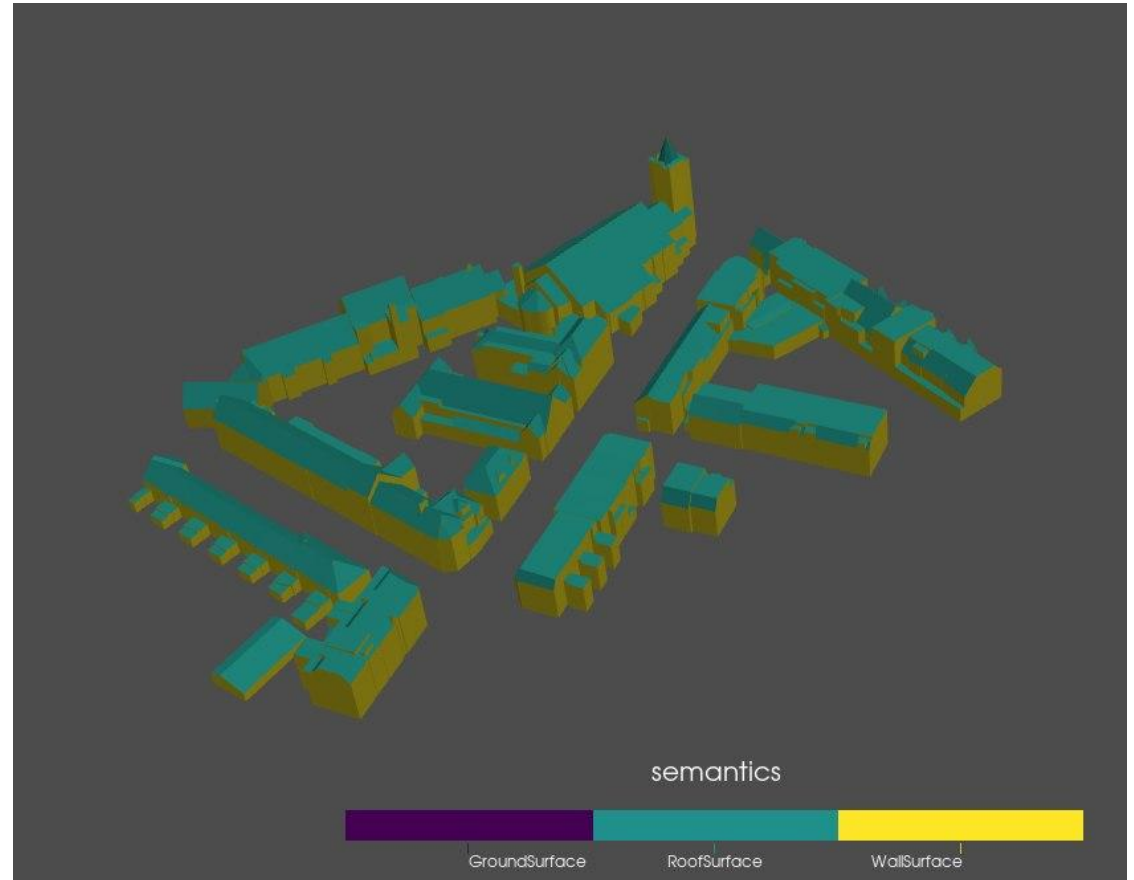
Sponsored by RVO



Calculation of party walls

Most semantic surfaces already assigned during reconstruction

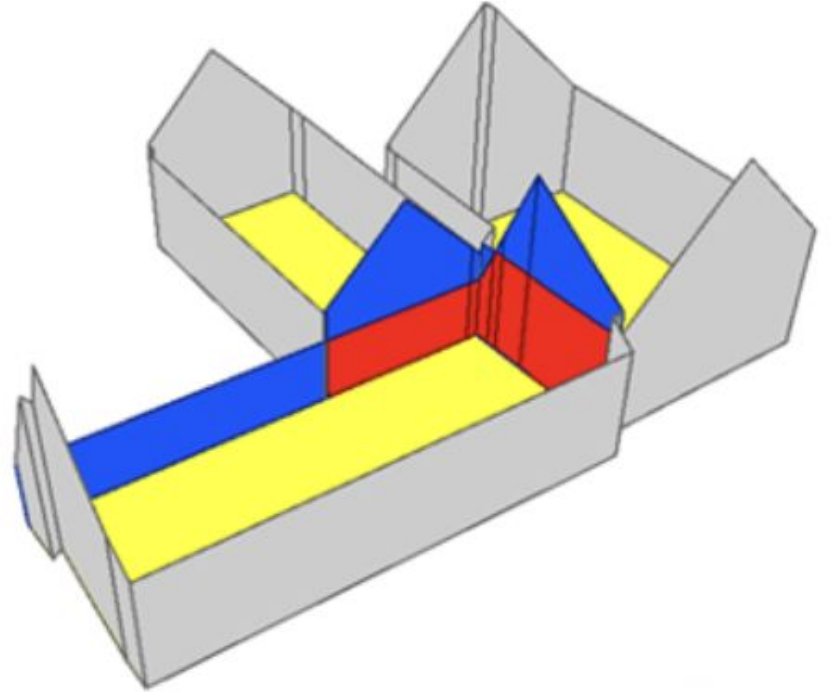
We just need to split *WallSurfaces* into party walls and exterior walls.



Calculation of party walls

For each building

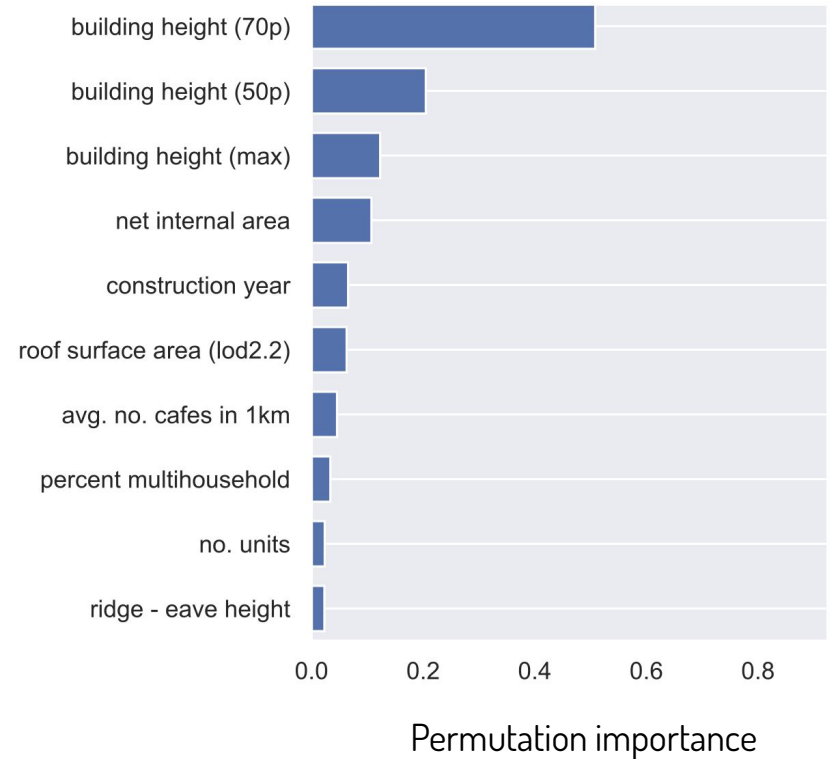
1. Find neighbouring buildings
2. Extract all 3D wall polygons
3. Find co-planar polygons through clustering by plane parameters
4. Intersect the co-planar wall polygons from different buildings.
5. Calculate area of intersection



Estimation nr of floors

Based on MSc thesis of [Ellie Roy \(Geomatics 2022\)](#)

- Machine learning method based on Gradient Boosting Regression
- Model trained on groundtruth data from a couple of Dutch municipalities
- Used features collected from various datasets (3DBAG, CBS, ...)
- Accuracy drops for >5 floors
- Available in 3DBAG release v2024.02.28



Thank you!

Ravi Peters

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Want to try the reconstruction algorithm yourself?

<https://github.com/geoflow3d/geoflow-bundle>