3D BAG

GE01004: 3D modelling of the built environment

Ravi Peters 02-06-2025



Faculty of Architecture and the Built Environment Delft University of Technology





The 3D BAG

3dbag.nl





A bit of background...

- Developed in 3D geoinformation group
 - To offer reliable & uniform height data for buildings
- Started as simple height attributes
 - Only LoD1.2
 - Used by practitioners, much feedback
- Co-developments within several research projects
 - Initial request for LoD1.3 models for Noise simulation NL
- First version of 3DBAG with LoD2.2 in 2021











3D BAG in practice

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



Reconstruction algorithm (<u>https://github.com/3DBAG/roofer</u>)

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 Detected planes 2 Ŧ 15

Feature extraction



Feature extraction **Detected lines** 17

Line regularisation

Using 2-step hierarchical clustering

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





(a) Detected lines



(c) Distance clustering



(b) Orientation clustering



(d) Regularised lines

Initial roof partition

Still many small faces





Graph-cut optimisation





Dual graph of planar arrangement

Zebedin et al. (2008)



Graph-cut optimisation

$$D_{p}(f_{p}) = \sum_{x \in p} \left| height_{PC}(x_{i}) - height_{f_{p}}(x_{i}) \right|$$

Data term:

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

Encourages good data fit by selecting candidate plane with smallest volumetric difference







heightfield f_2 f_1 f_5 f_4 f_3 f_7 f_6 1.1

 f_5

Graph-cut optimisation

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

Smoothness term:

Edge length between adjacent faces

Minimisation entails:

- Short and simple edges
- 'Merging' of faces,



Final roof partition







Extrusion



Effect of complexity term λ



Image by Ivan Pađen

Special cases, Limitations



In some cases BAG footprint includes groundparts

AHN3 ground and building class



BAG footprint



Reconstruction result: roofplane fitted to groundpart





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

Occlusion/no-data



Reconstruction



AHN3 ground and building class



Heightfield





Occlusion effect on reconstruction



Fuse two point clouds







Data management

How to tile the data?





How to tile the data?





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 filesizes manageable the 3DBAG dataset is subdived 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 2	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.

Туре	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/

3DBAG tech stack



Data orchestration pipeline



3DBAG repositories

https://github.com/3DBAG

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README.md P 3DBAG	 View as: Public You are viewing the README and pinned repositories as a public user. Get started with tasks that most successful 	
This is the GitHub organisation of the 3DBAG Innovation Platform. This place is used for collaborating on the software that used for producing the 3DBAG, for organising the 3DBAG development and communicating with the 3DBAG users and contributors. The main platform for communication are the <u>Discussions</u> . If you have any questions or comments about the 3DBAG in general, about a specific software or you spotted an error, please review first if you question has been answered already. If not, don't hesitate to open a new discussion. The software that you will find in this organisation:	Top discussions this past month Discussions are for sharing announcements, creating conversation in your community, answering questions, and more.	
<u>3dbag-api</u> : OGC Features API that serves the 3DBAG CityJSON data at <u>https://api.3dbaq.nl/</u> <u>3dbag-dashboard</u> : Quality dashboard for the 3DBAG at <u>https://3dbaq.nl/en/dashboard</u>	Start a new discussion	
<u>3dbaq-docs</u> : The 3DBAG documentation at <u>https://docs.3dbaq.nl/en/</u> <u>3dbaq-pipeline</u> : Production pipeline that orchestrates source data ingestion, preprocessing, building reconstruction, postprocessing and deployment <u>3dbaq-viewer</u> : The 3D viewer at <u>https://3dbaq.nl/en/viewer</u> <u>CityBuf</u> : Experimental CityJSON encoding as FlatBuffers <u>geodepot</u> : Test data management system for geodata <u>peodepot-ani</u> : API to a geodenot repository.	People	
<u>geodeportage</u> , Arr to a geodeportepository <u>roofer</u> : Automatic LoD2.2 building reconstruction that generates the 3D building models of the 3DBAG	Top languages	

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3DBAG additions

3DBAG API

Request directly CityJSON Features by

- Building ID
- Bounding box

Based on <u>CJDB</u> (2022 geomatics synthesis project)

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$\leftarrow \rightarrow \mathbf{C}$ $\bigcirc \mathbf{A}$ https:	//api.3dbag.nl/collections/pand/items/NL.IMBAG.Pand.1655100000500568 🔂	⊠
JSON Onbewerkte gegevens Headers		
Dpslaan Kopiëren Alles samenvouwen Alles uitv	ouwen 🛛 JSON filteren	
feature:		
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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:	8.60000381469727	
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:		
b3_nodata_radius_ahn3:	0.992850124835968	
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_puntdichtheid_ahn3:	14.450262069702148	
b3_puntdichtheid_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	
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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 <u>Ellie Roy (Geomatics</u> 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



3DBAG future work

Future work

- Data updates
 - Eg. when new pointcloud is available
- Further improve geometric validity
 - Already > 99% is valid, but there are still some issues
- More efficient data exchange format
 - CityJSON has some limitations (text based, requires parsing)
 - "FlatCityBuf" a binary flatbuffer encoding of CityJSONSequences
 - No parsing needed, thus faster reading and more memory efficient
 - Also suitable for 'cloud native' applications
- Address defects in point cloud caused by eg. occlusion
 - Using 'RoofDiffusion' approach?

https://github.com/kylelo/RoofDiffusion



Thank you!

Ravi Peters ravi.peters@3dgi.nl

Want to try the reconstruction algorithm yourself?

https://github.com/3dbag/roofer