Netherlands Enterprise Agency

Ministry of Housing and Spatial Planning

kadaster

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

hetWaterschapshuis

Gemeente Amsterdam

Gemeente Utrecht

GEONOVUM

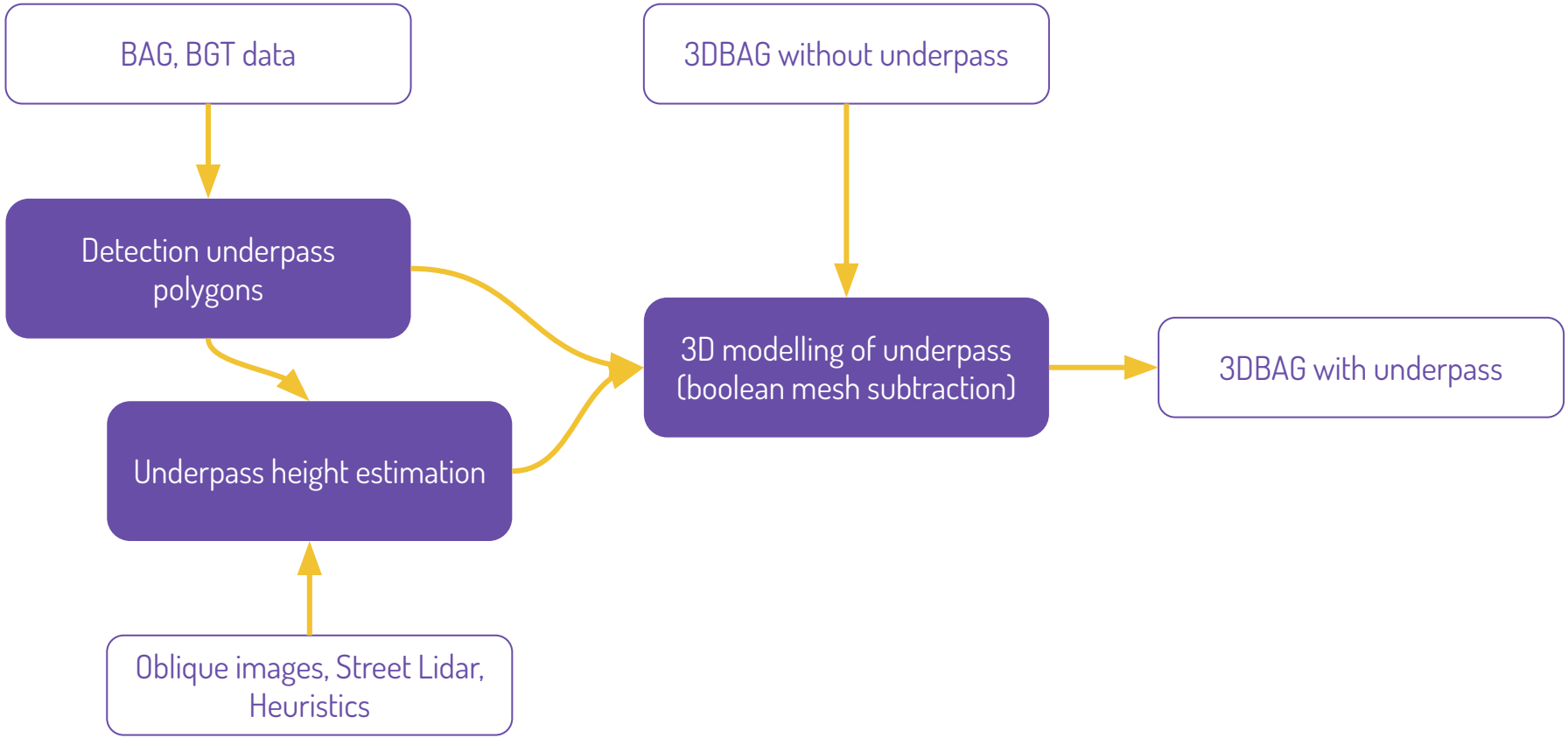
Innovatieve algoritmes voor betrouwbare, stedelijke 3D-modellen

Update, 19 Januari 2026
Online

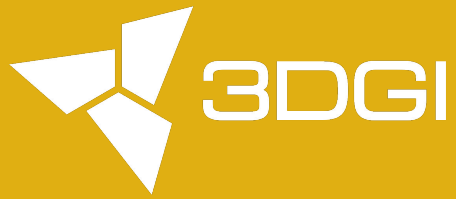
3DGI

TU Delft 3Dgeoinfo

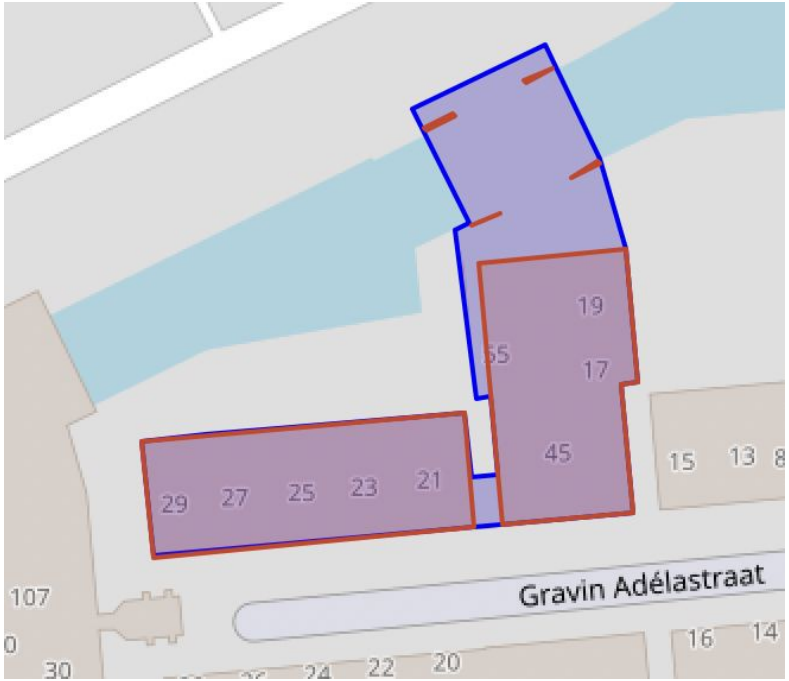
Overview technical components



Detection of Underpass Polygons



Methodology



BAG - BGT

Underpasses

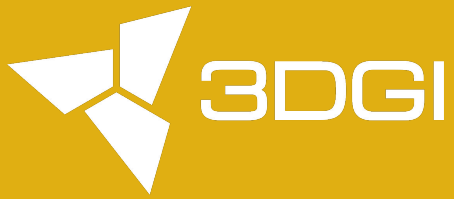
Detection in Rotterdam

Next step: detect type of underpass (semantic enrichment)

Pedestrian path through buildings

Car access

Underpass Height Estimation



Underpass Height Estimation

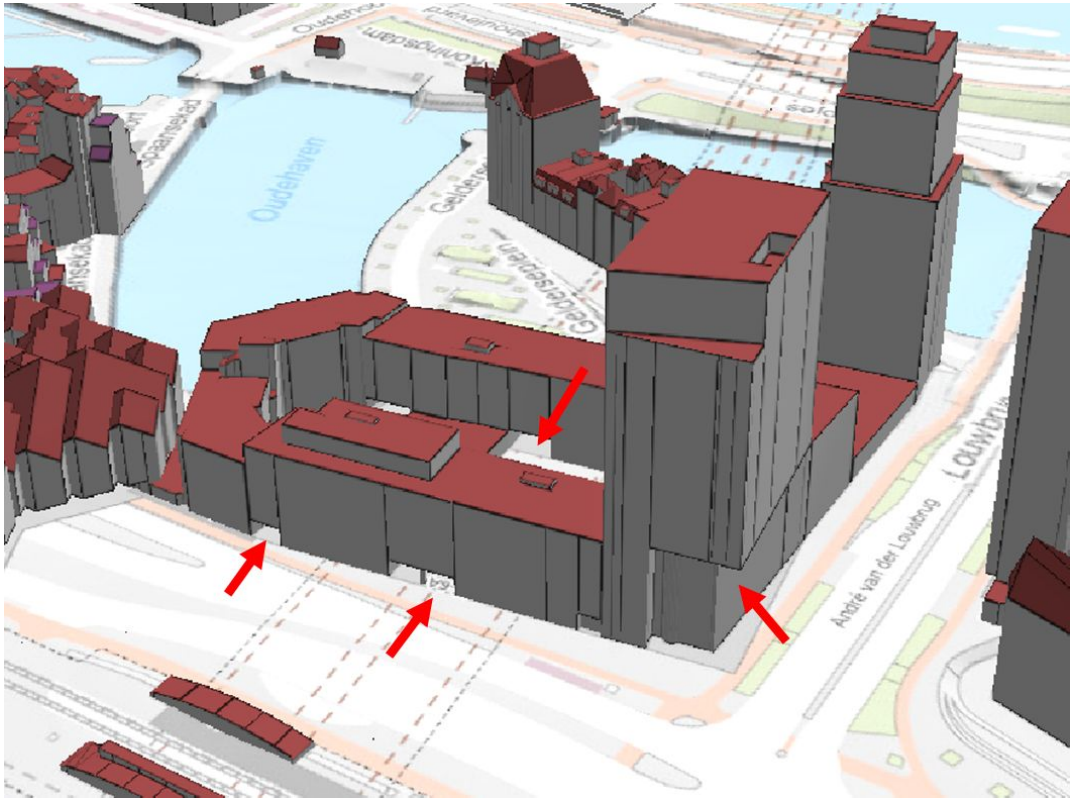
Oblique Aerial Images

SpoorInBeeld, ProRail

Lidar

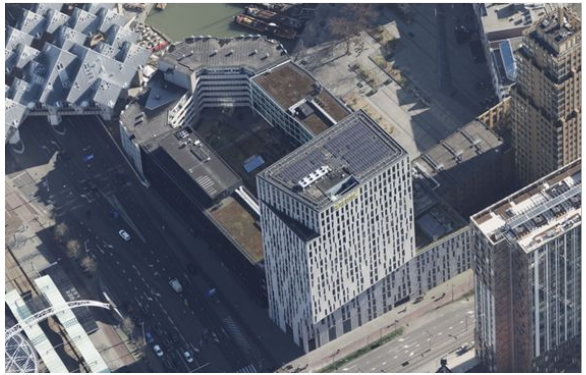
AHN5

Geldersplein 50 - Rotterdam



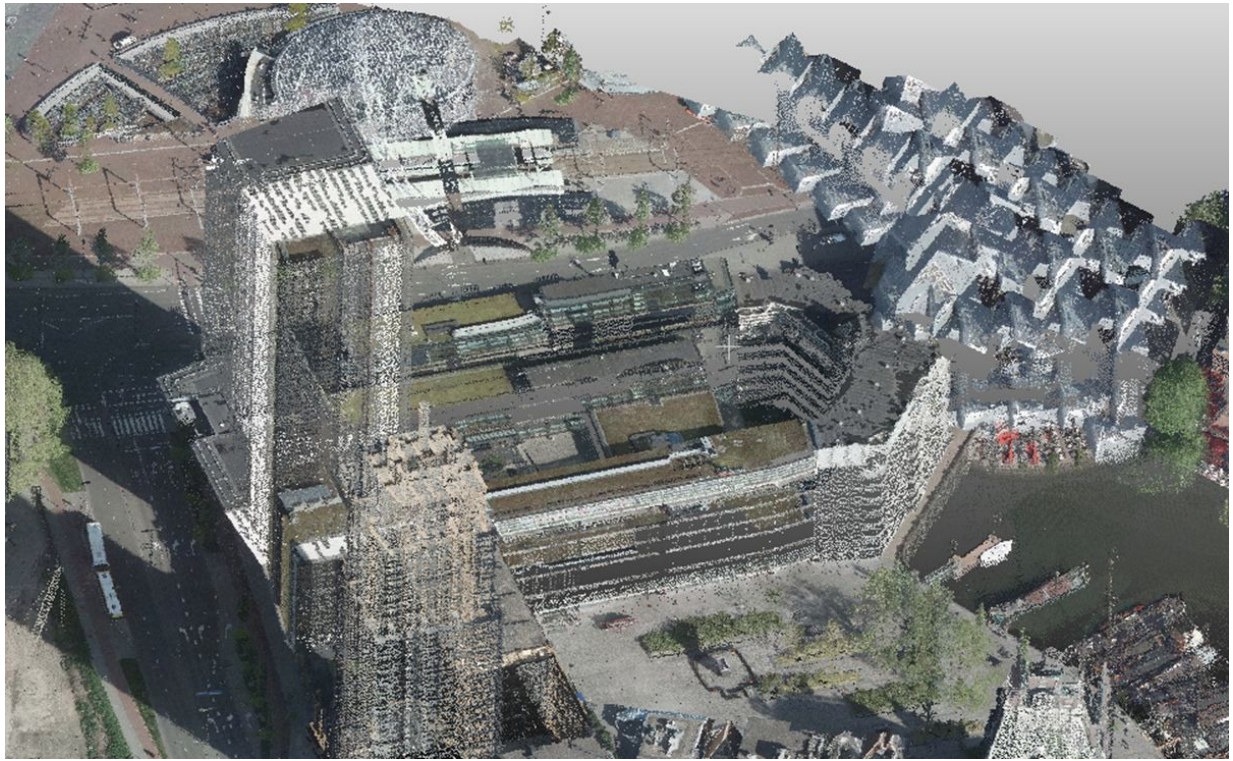
Rotterdam3d

Geldersplein 50 - Rotterdam



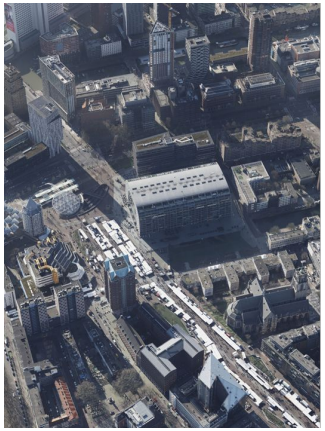
3dgeoinfo

Geldersplein 50 - Rotterdam



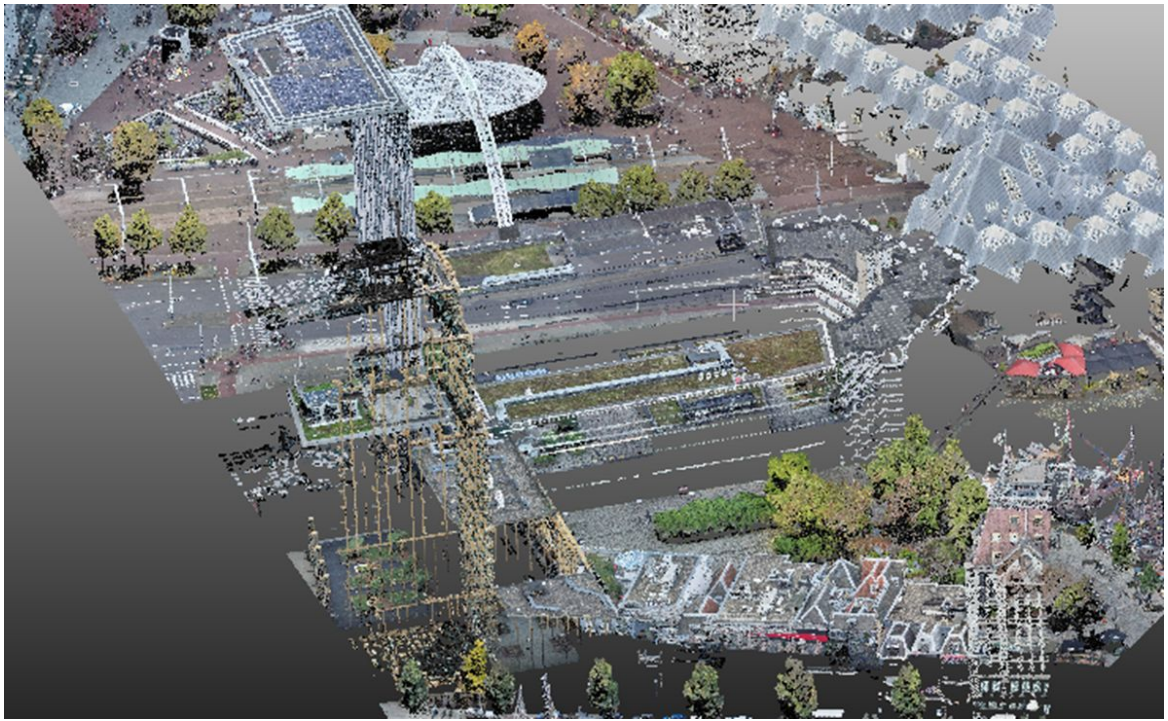
3dgeoinfo

Geldersplein 50 - Rotterdam



ProRail

Geldersplein 50 - Rotterdam



ProRail

Beemsterstraat 42 - Amsterdam

Municipality data

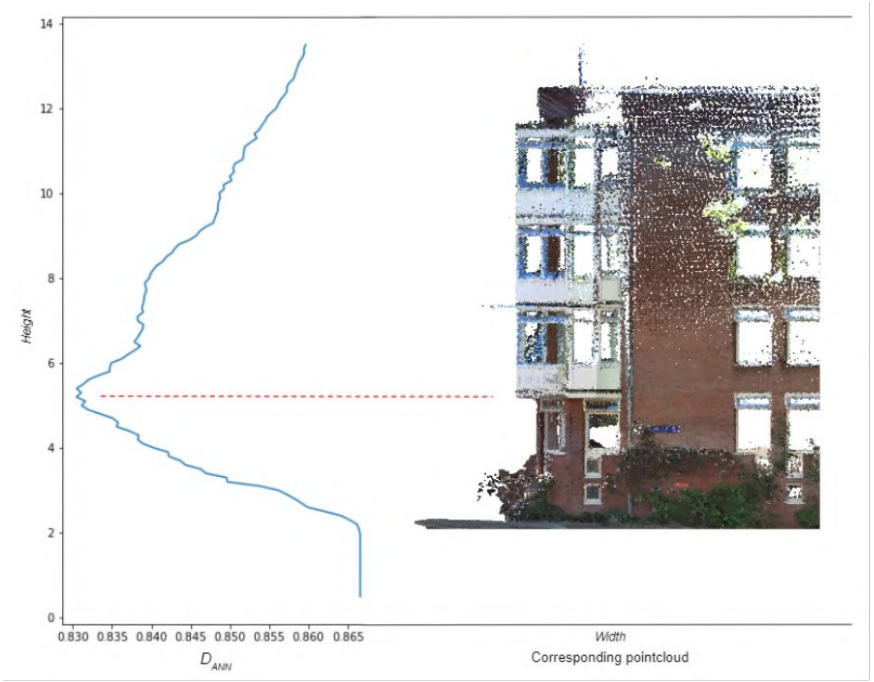
Beemsterstraat 42 - Amsterdam

Municipality data

Beemsterstraat 42 - Amsterdam

3dgeoinfo

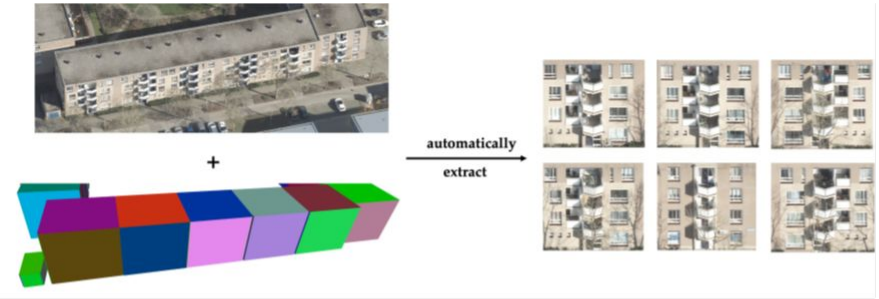
Approach 1 - using point cloud data



1. Sample points from already existing 2.5D model (3DBAG) → set ***M***
2. Extrude 2D polygon and sample points → set ***N***
3. Compute intersection of ***M*** and ***N*** at different heights → Candidate model
4. Compare each candidate model to real point cloud. Estimate height based on similarity with real point cloud

Augmented and Guided City-Scale Facade Reconstruction using Terrestrial Point Clouds and Prior Building Knowledge (Bob Leijnse, 2022)

Approach 2 - using oblique imagery



A data-driven approach to add openings to 3D BAG building models (Y. Xia, 2023)

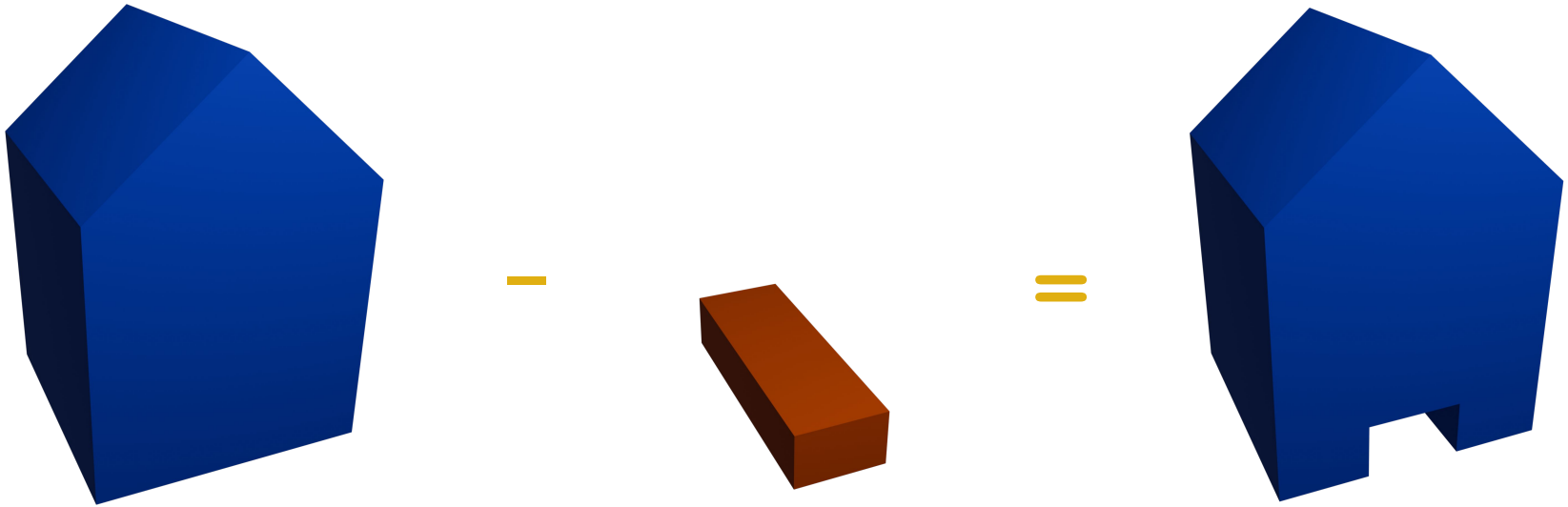
1. Project 3D facade on oblique images → extract facade region
2. Adjust projection → straighten facade
3. Detect underpass
4. Estimate height

3D modelling of underpass (boolean mesh subtraction)

3DGI

TU Delft 3Dgeoinfo

3D modelling of underpass (boolean mesh subtraction)

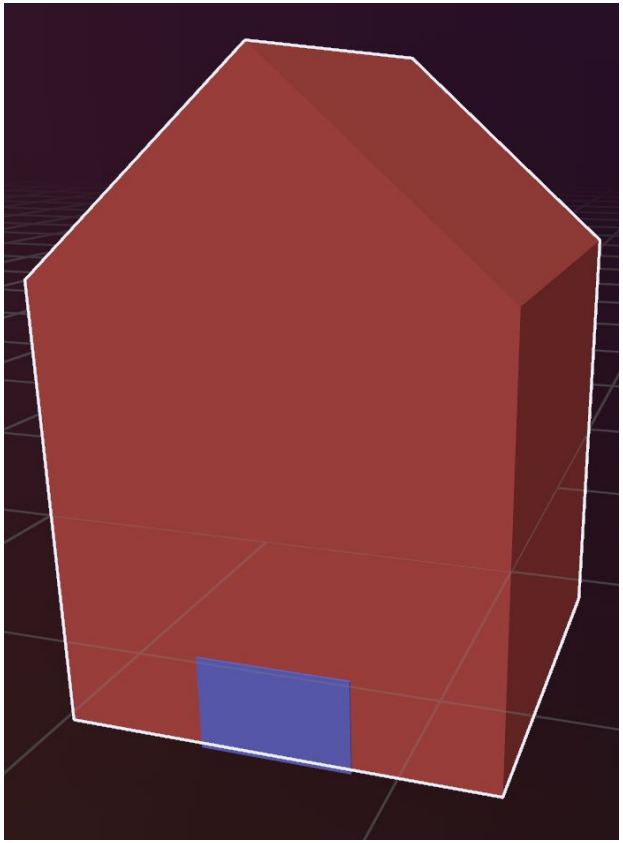


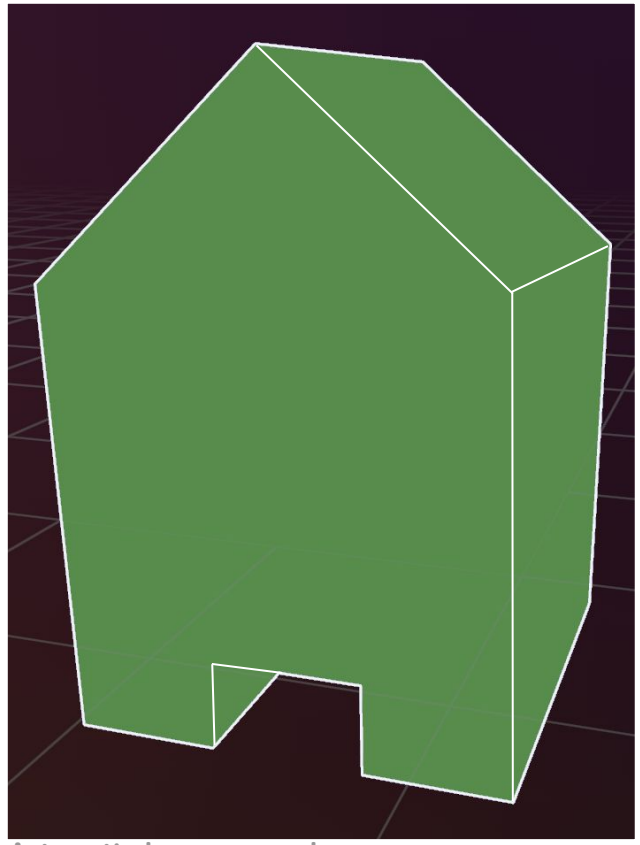
Handmatig gegenereerd

3D modelling of underpass (boolean mesh subtraction)

- 3 kandidaat software bibliotheken: *CGAL*, *geogram*, *manifold*
- Begonnen met eerste implementatie op basis van *manifold* en simpele data
- Volgende stappen:
  - Inlezen van 3DBAG model + polygoon onderdoorgang met hoogte
  - Implementatie andere kandidaten
  - vergelijking van 3 kandidaten voor groter testgebied op
    - snelheid
    - kwaliteit
    - betrouwbaarheid

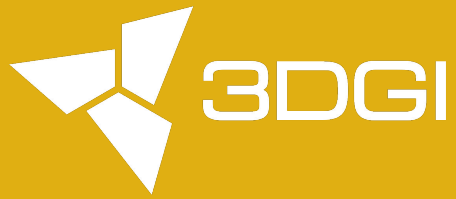
3D modelling of underpass (boolean mesh subtraction)





Automatisch gegenereerd

Use cases



Use cases: aanvullingen, illustraties?

1. Visualisatie & participatie
   - realistischer stadsmodellen voor communicatie met bewoners en stakeholders.=
2. Mobiliteit, bereikbaarheid/veiligheid
   - vluchtroutes, doorstroom- en crowd management (event/gebied).
   - verkeersstromen door gebouwencomplexen (overkluizingen/kubuswoningen Rotterdam).
3. Energie, klimaat, omgeving
   - compactheid, schaduw/koelte-routes (hittestress), potentiële input voor warmteverlies-/windsimulaties. Urban heat island
   - Geluidsimulatie
   - Overstroming
   - (Modelling stables for animals, estimating how many cattle)
4. Innovatie potentieel
   - Bruggen: vergelijkbare problematiek (hoogte-invulling waar data ontbreekt); mogelijk hergebruik heuristieken.
   - Viaducten
   - Aantonen nut van bv oblieke beelden, aanmoedigen nationale inwinning.

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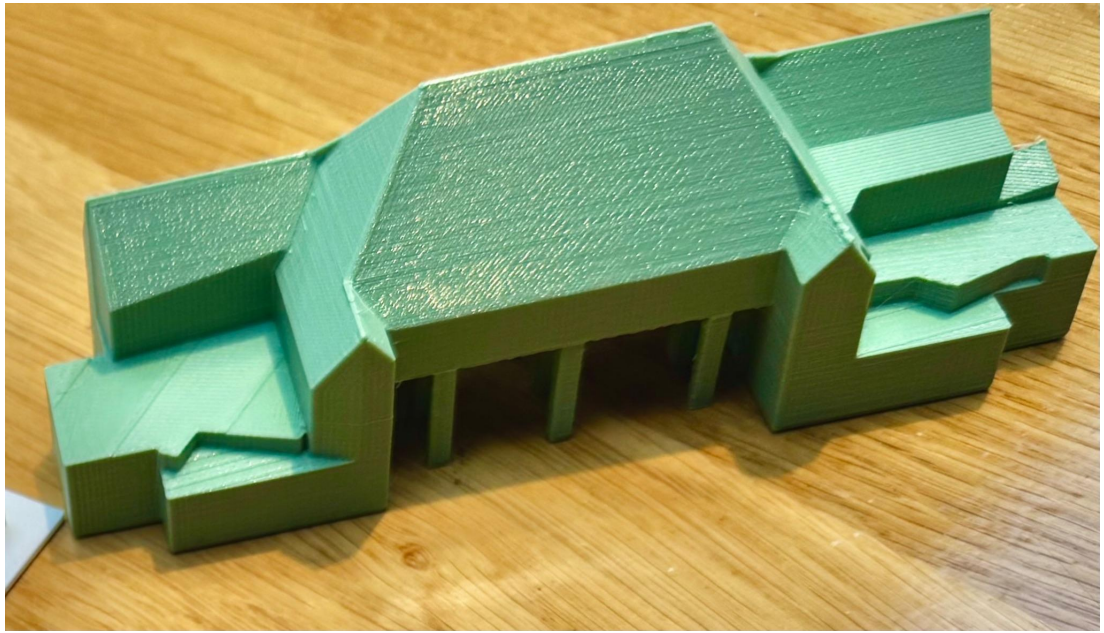
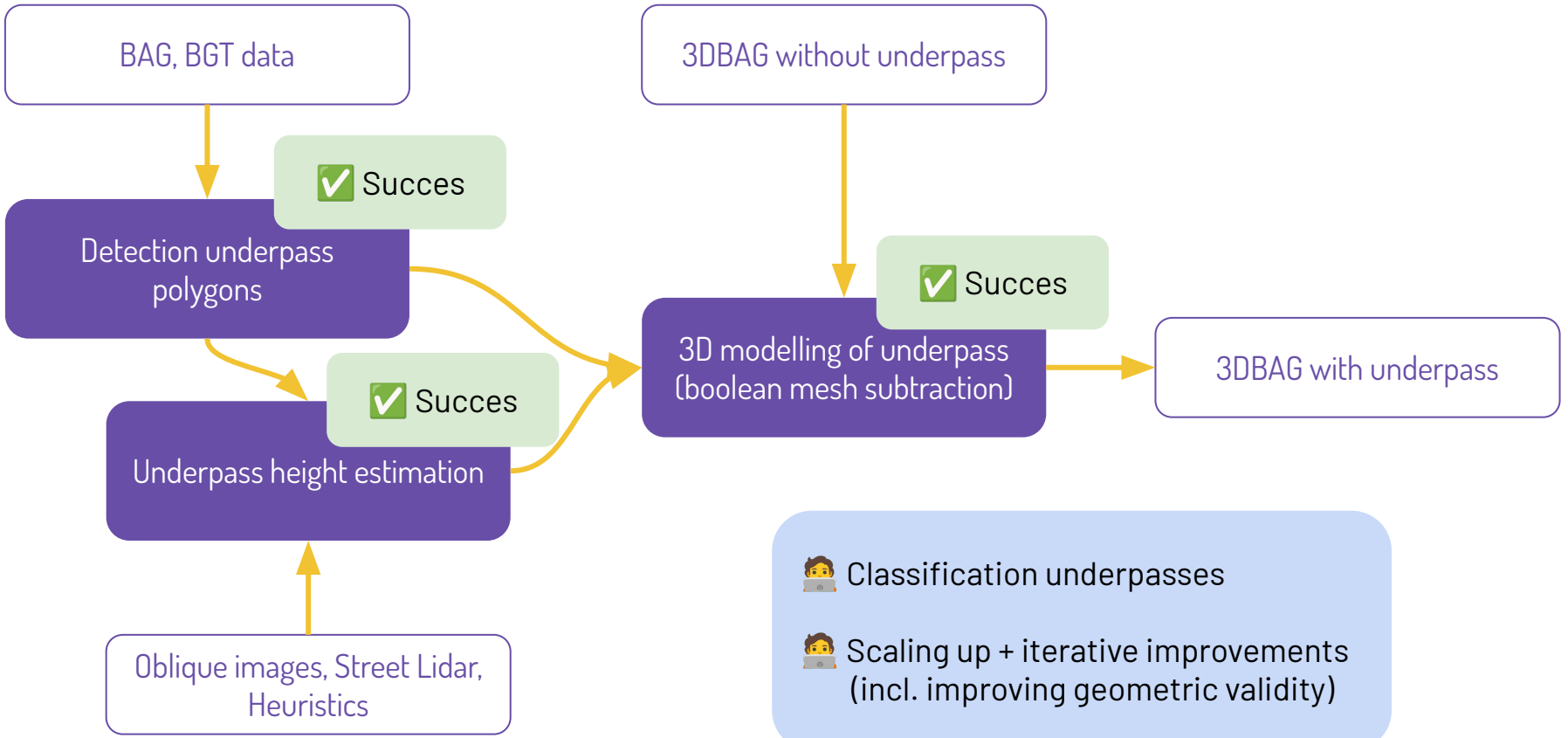


3DGI

TU Delft 3Dgeoinfo

Status update



Classification of Underpasses (semantic enrichment)

Type classification

Arcade

Pedestrian path through buildings

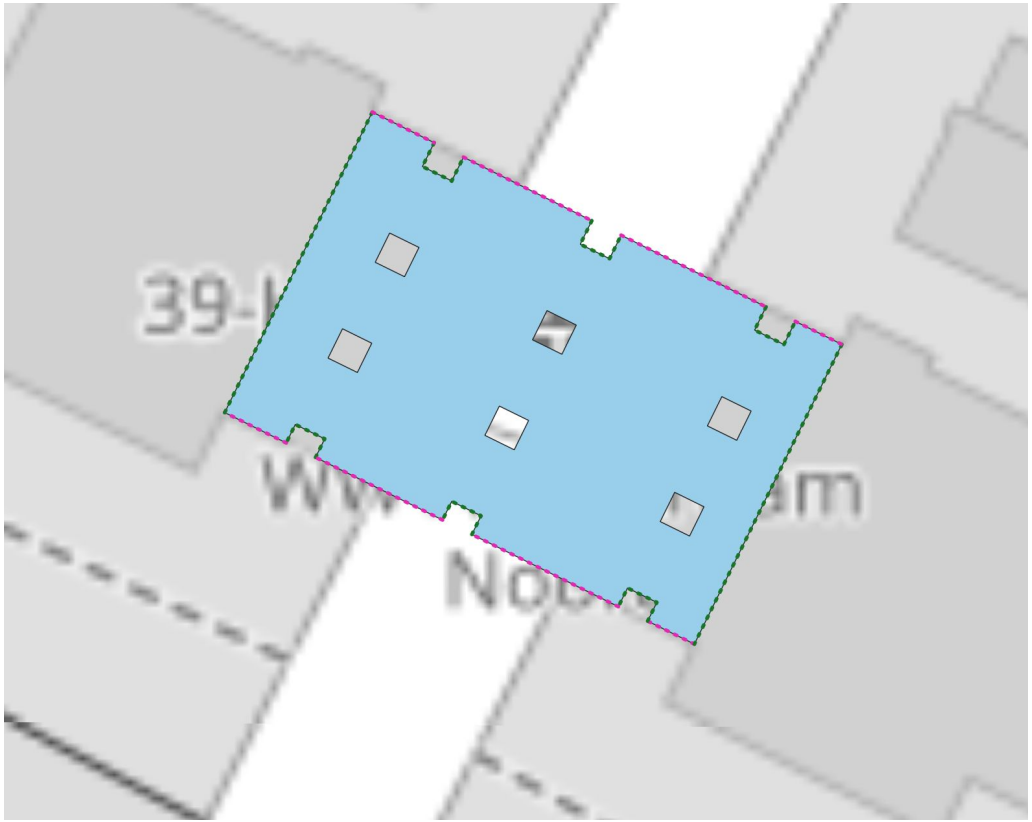
Pass-through with car access

Important for Disaster Management

Type classification

Topological classification based on the edges of the detected underpass:

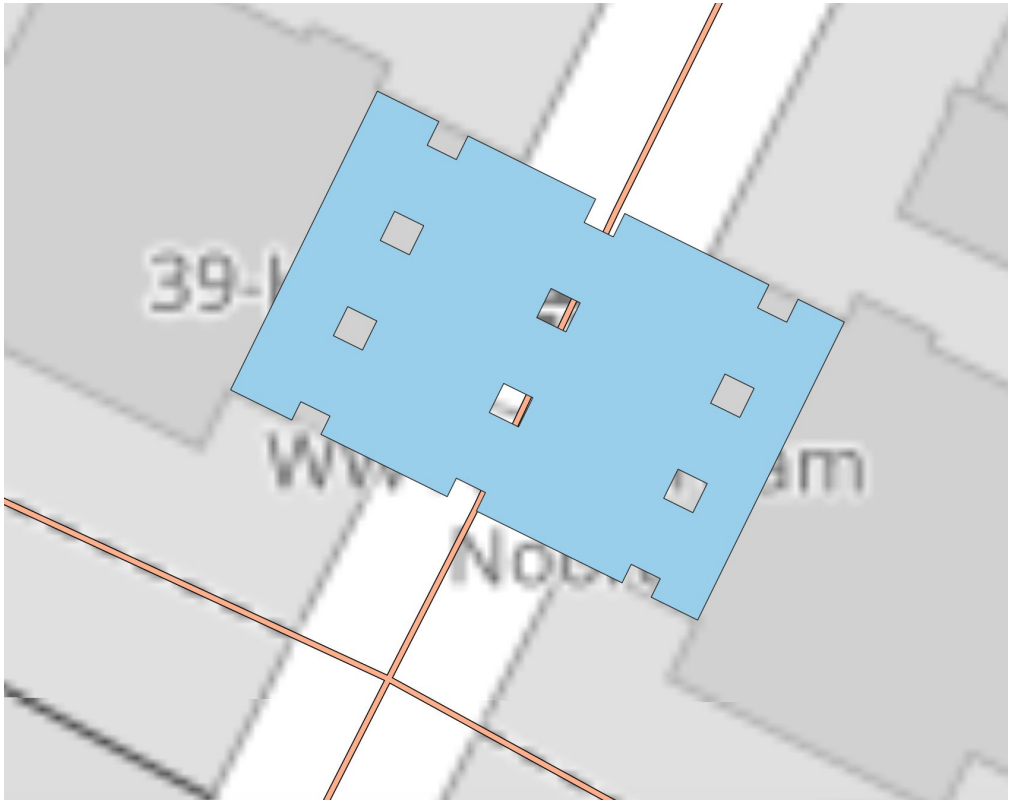
If the underpass has more than one exterior edge (eg exit) than it is is a “pass-through” underpass.



Type classification

Accessibility classification based on intersections with road network:

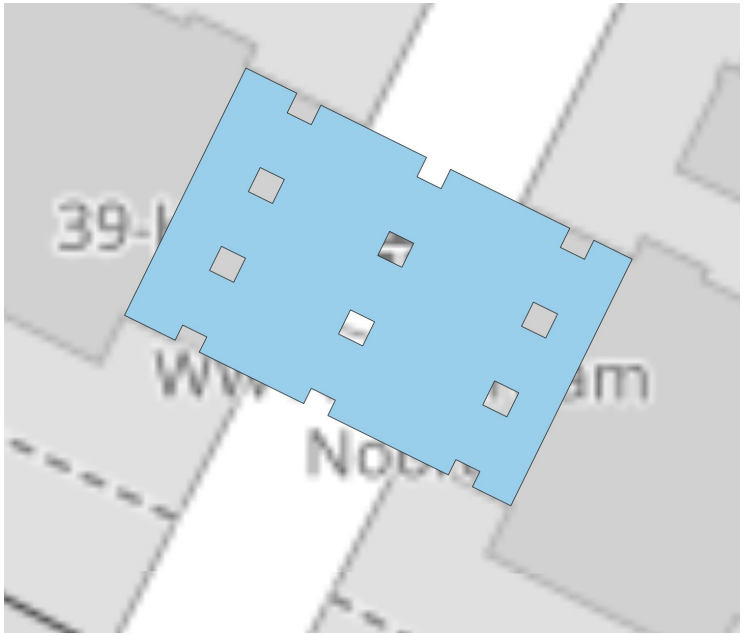
If the underpass intersects with road segments the it is classified as " car accessible" otherwise "pedestrian-only".



Type classification

Beemsterstraat 42

A “car-accessible, pass-through”



Type classification

Weesperstraat 430

A “pedestrian-only, pass-through”

Type classification

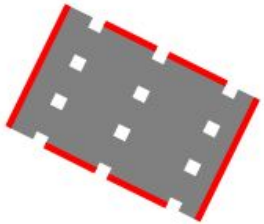
Sarphatistraat 129

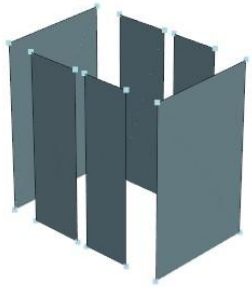
An “arcade, pedestrian-only”

Hoogtebepaling uit oblique luchtfoto

Beemsterstraat

Perspective projection





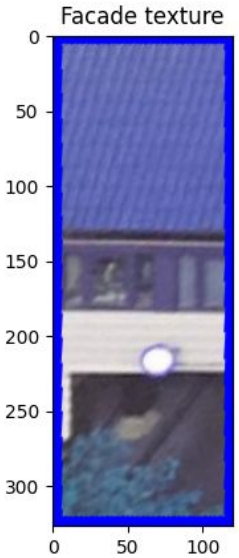
Beemsterstraat

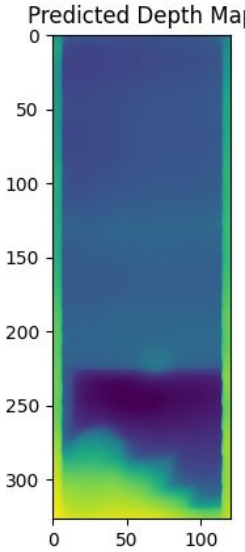
Perspective projection

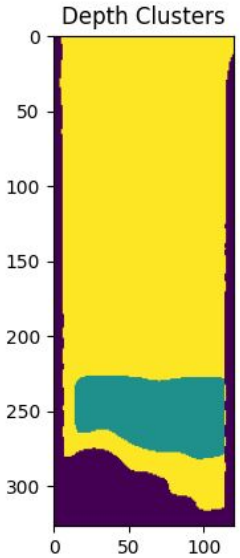
- Highly reliable in camera parameters accuracy

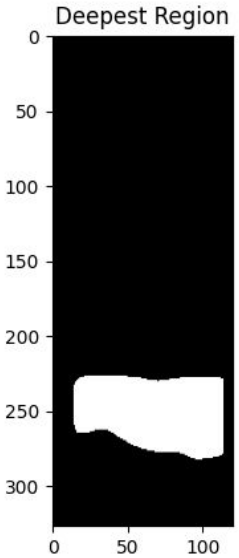
Beemsterstraat

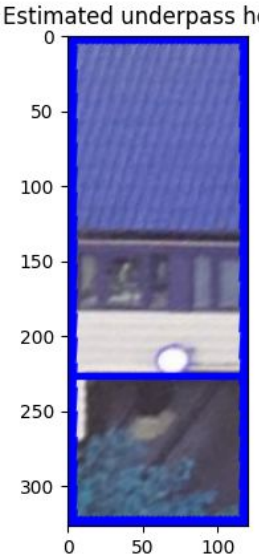
Depth Map Method







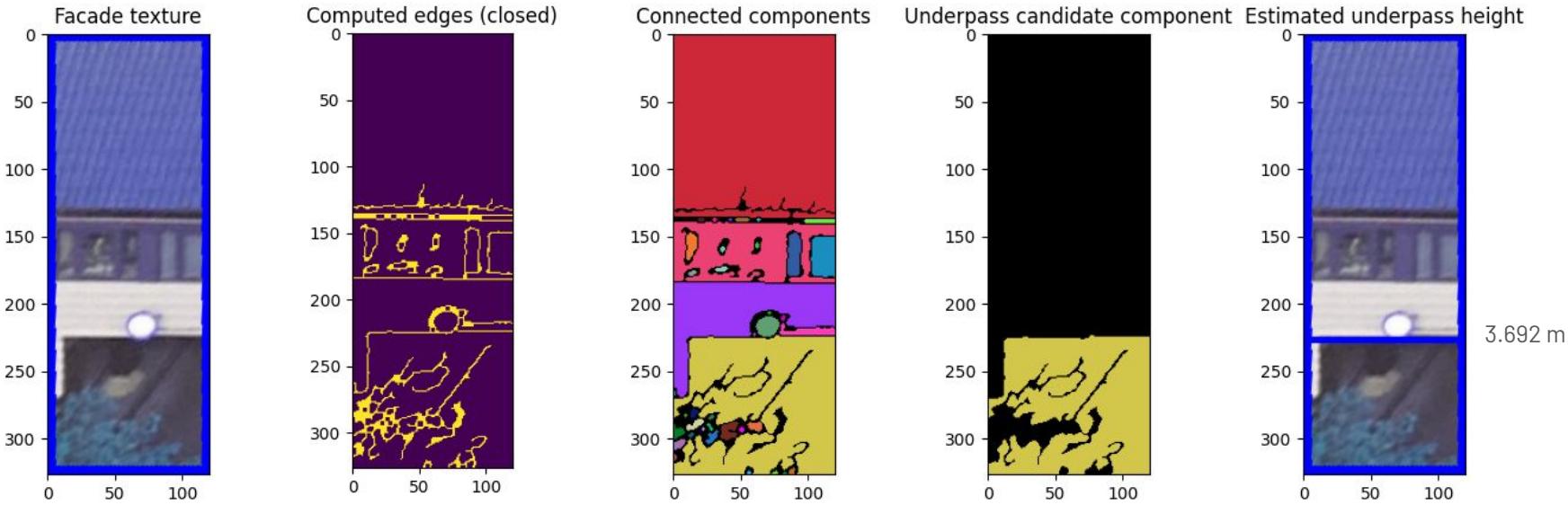




3.584 m

Beemsterstraat

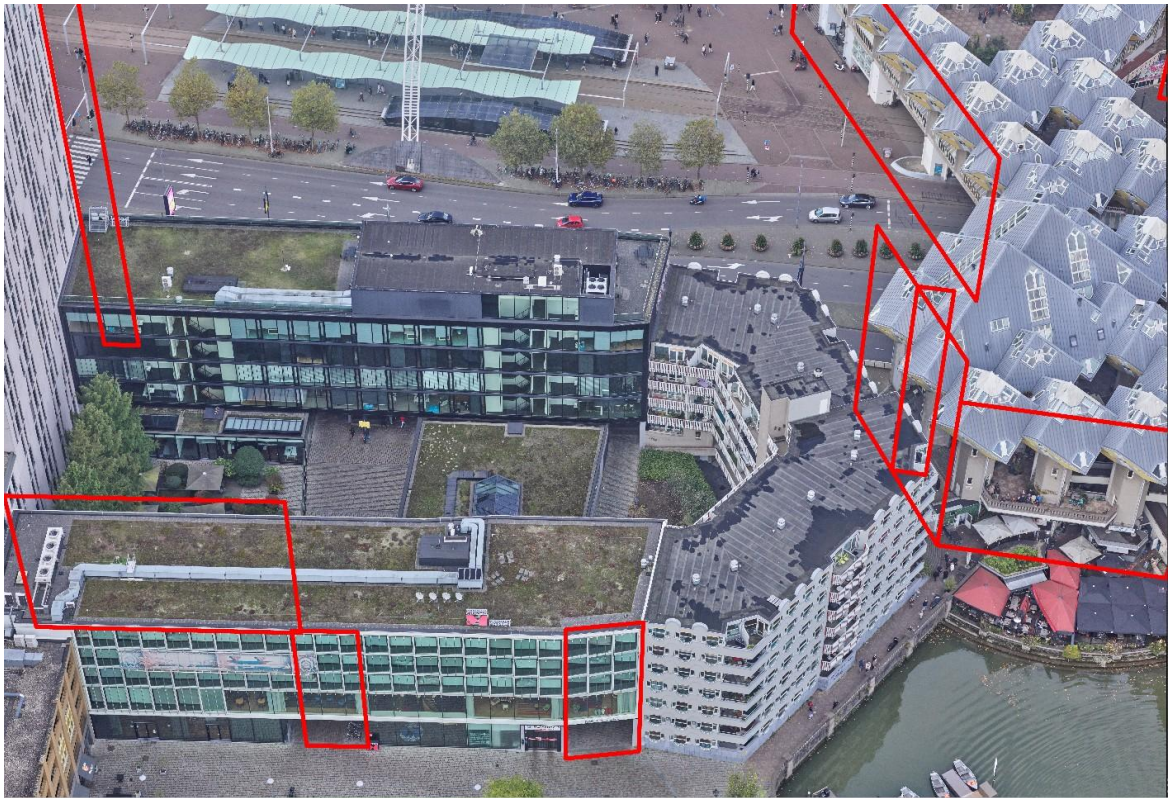
Connected Components Method



Gelderseplein

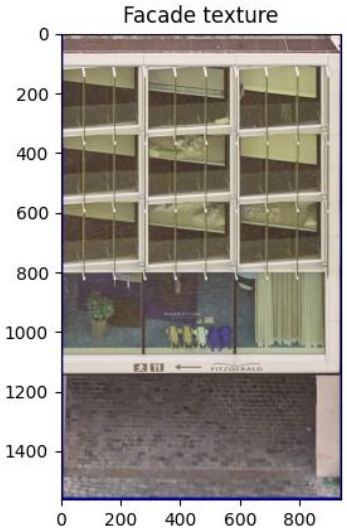
Perspective projection

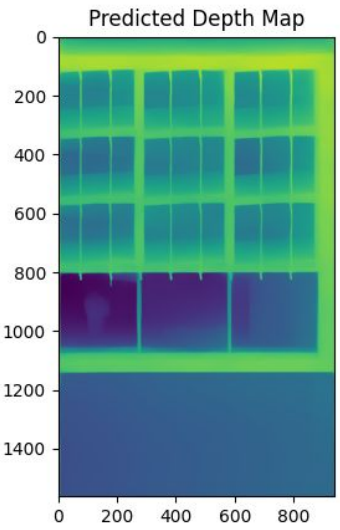
- ProRail data

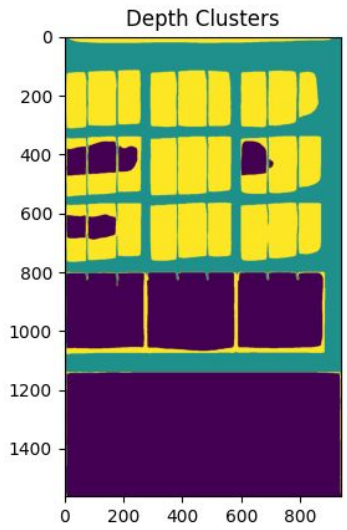


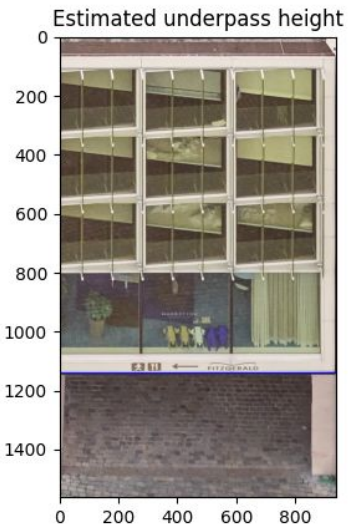
Gelderseplein

Depth map method





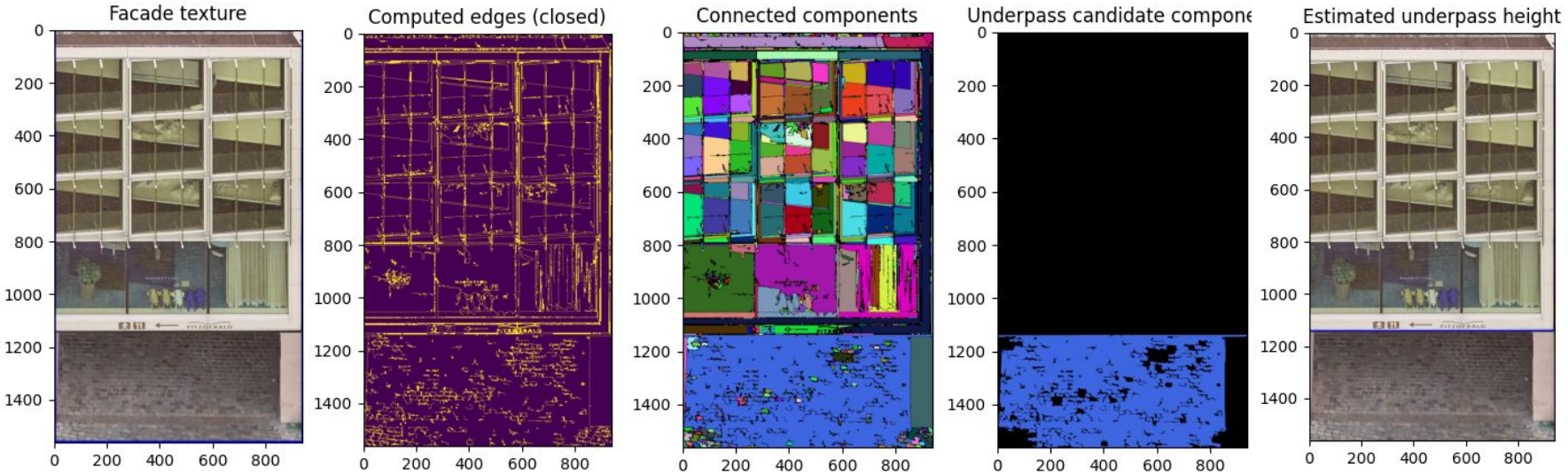




5.695 m

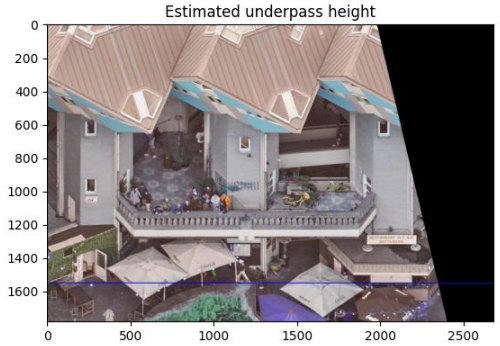
Gelderseplein

Connected components method

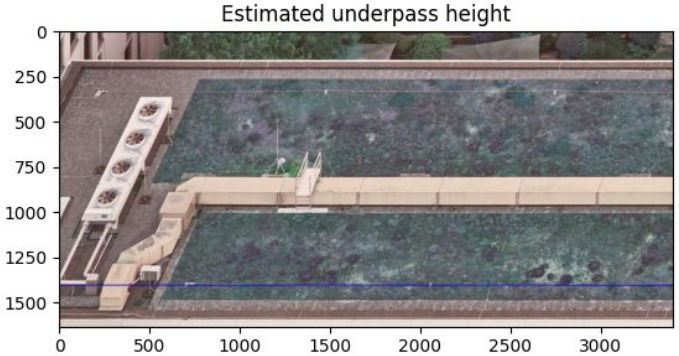


5.734 m

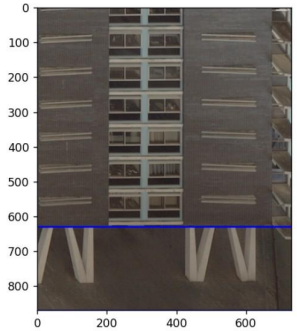
Challenges



Presence of city objects

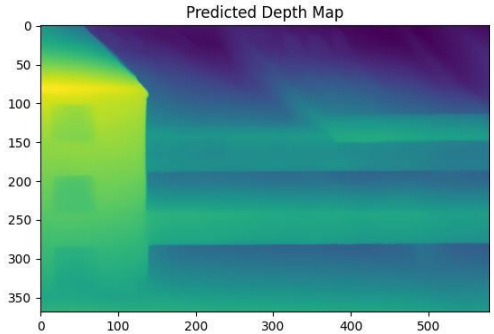


Extraction of wrong images

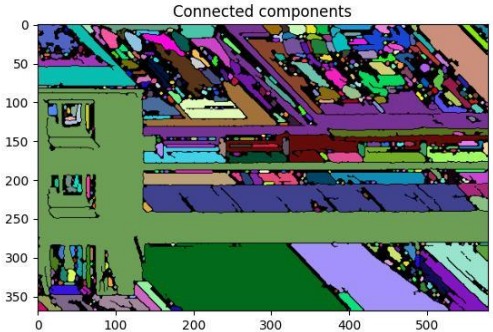


Facade misalignments

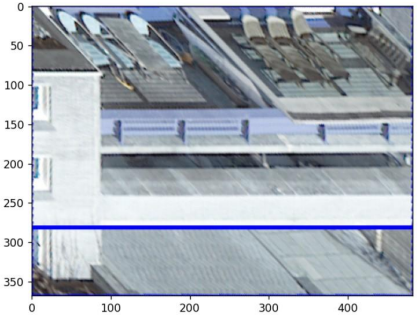
(Projection inaccuracies)



Computationally heavy



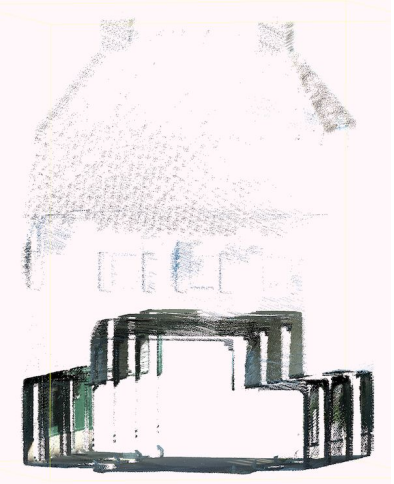
No semantic understanding



Vertical distortions

Hoogtebepaling uit streetview Lidar

Beemsterstraat



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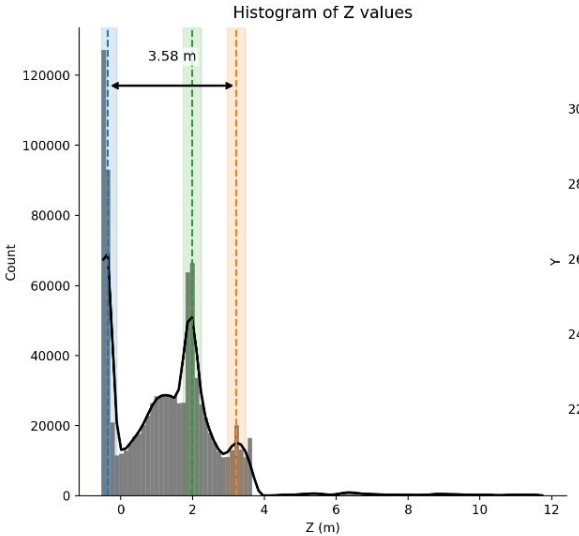

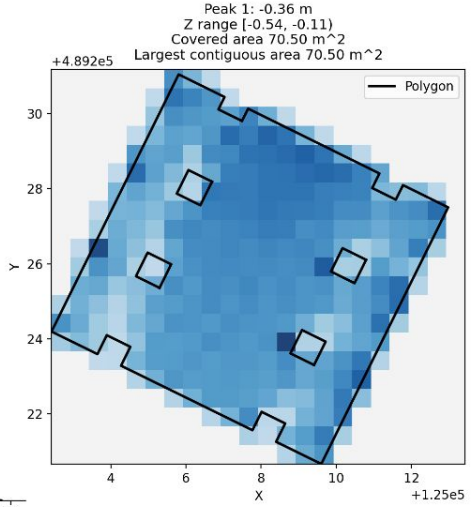

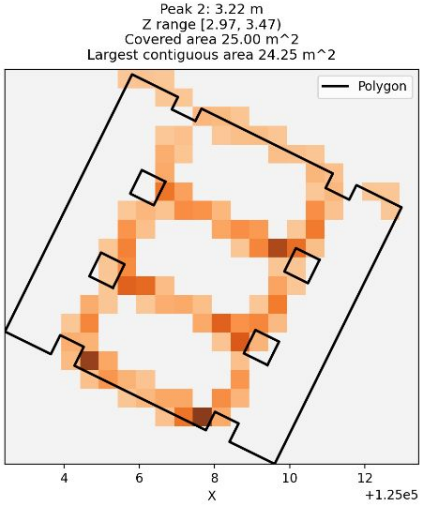

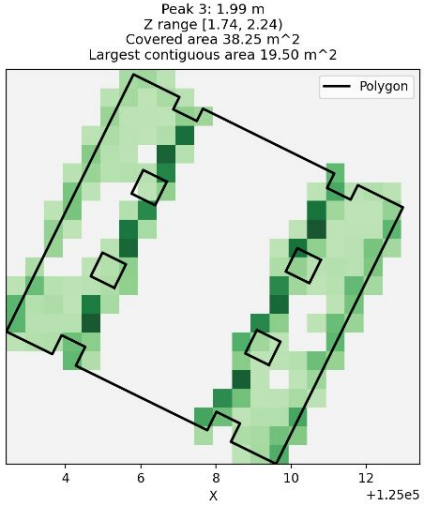

Beemsterstraat

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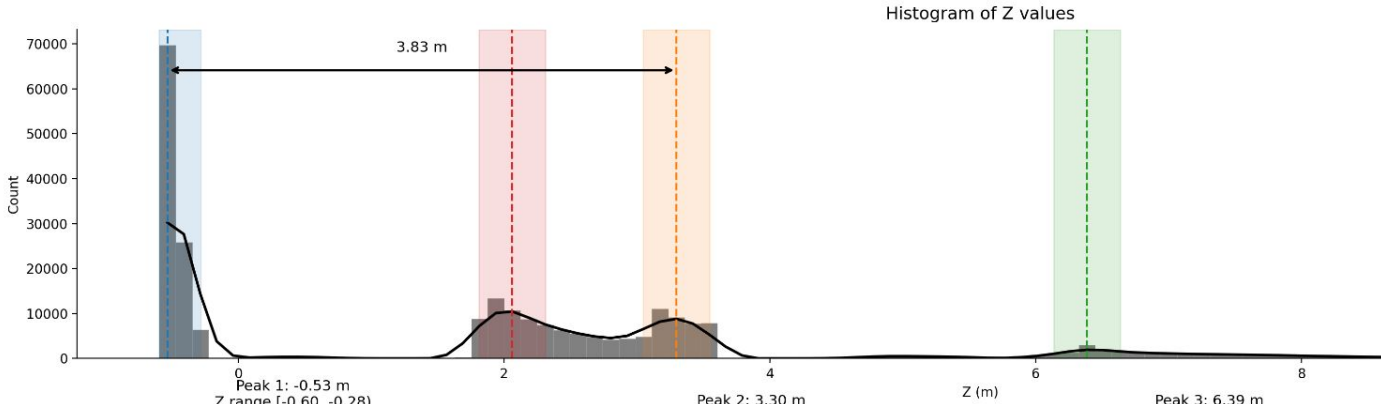
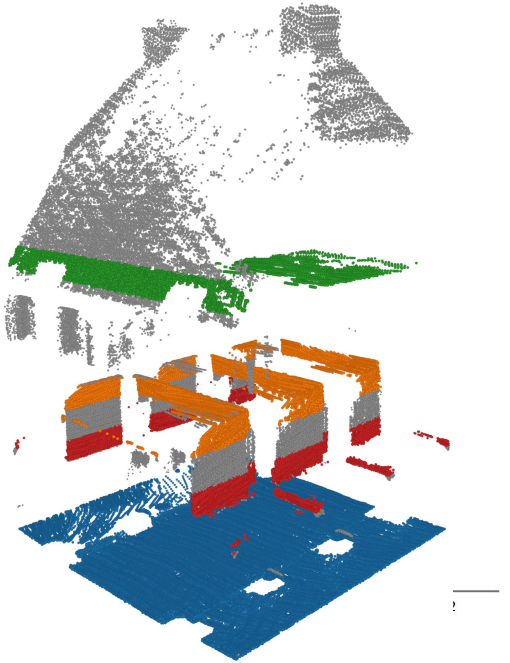
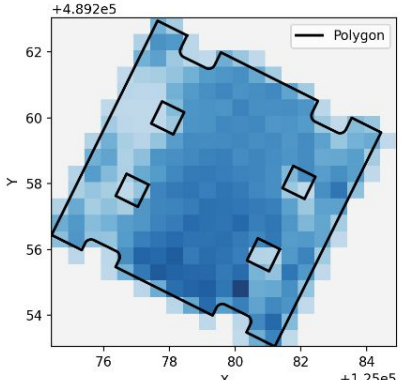
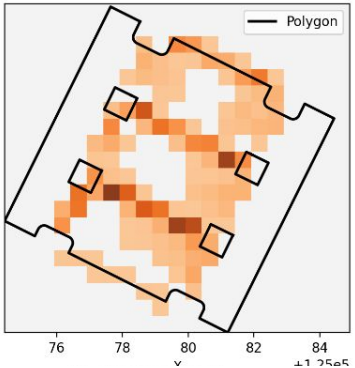




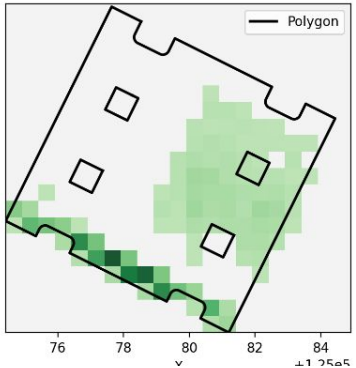
Peak 1: -0.53 m
Z range [-0.60, -0.28)
Covered area 63.25 m^2
Largest contiguous area 63.25 m^2



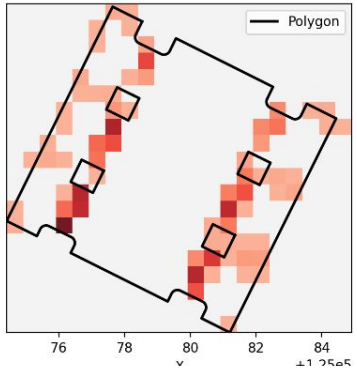
Peak 2: 3.30 m
Z range [3.05, 3.55)
Covered area 27.50 m^2
Largest contiguous area 27.50 m^2



Peak 3: 6.39 m
Z range [6.14, 6.64)
Covered area 24.25 m^2
Largest contiguous area 17.25 m^2

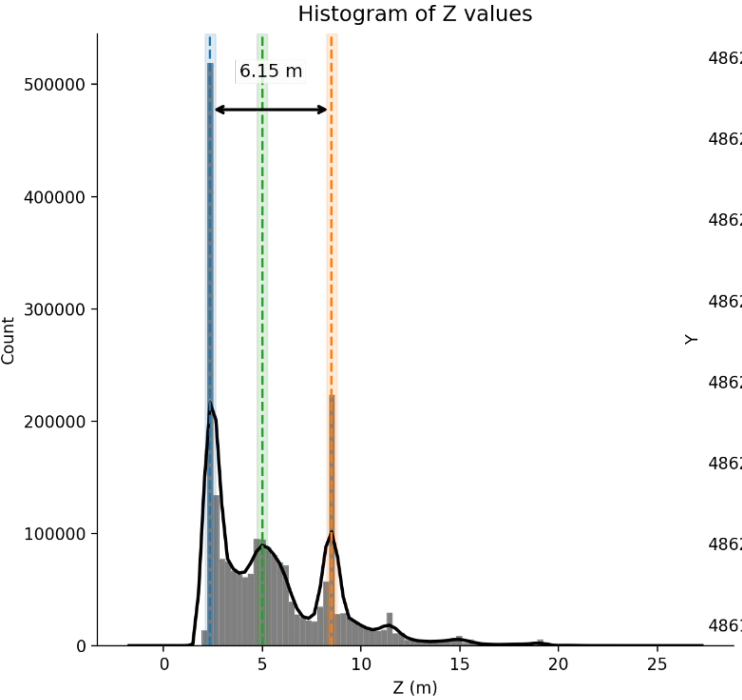


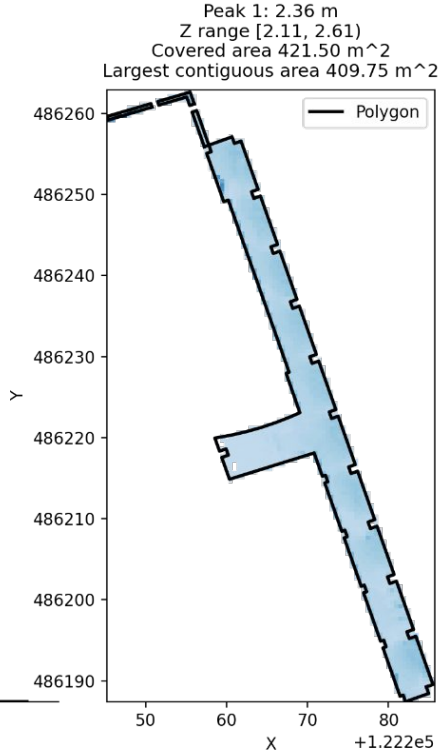
Largest contiguous area 7.75 m^2

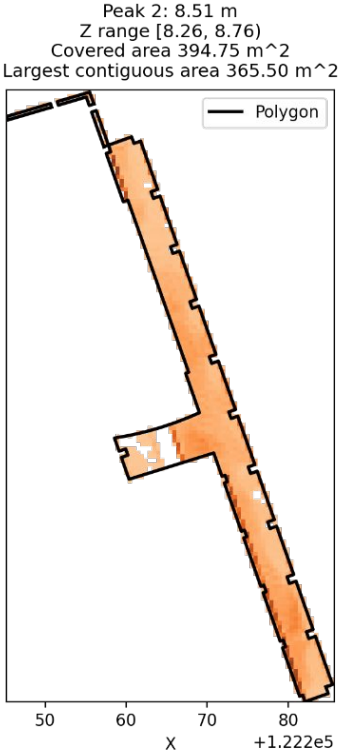


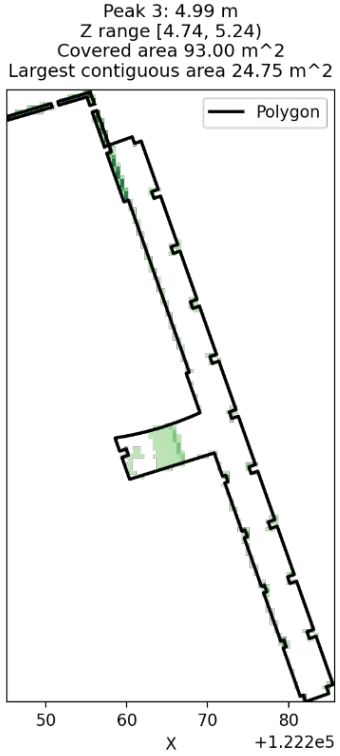
Weesperstraat

NL.IMBAG.Pand.0363100012170850

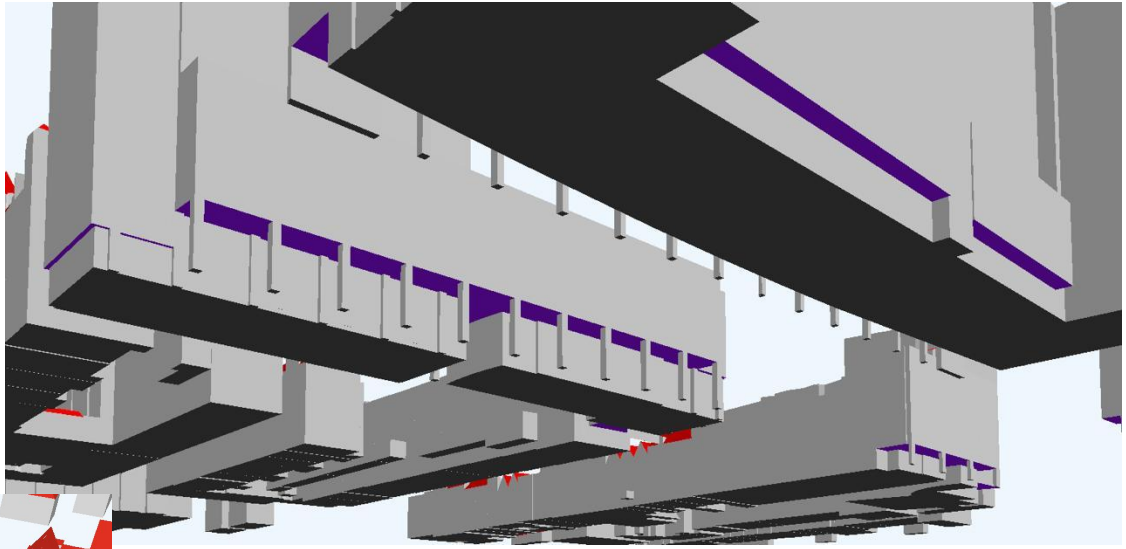


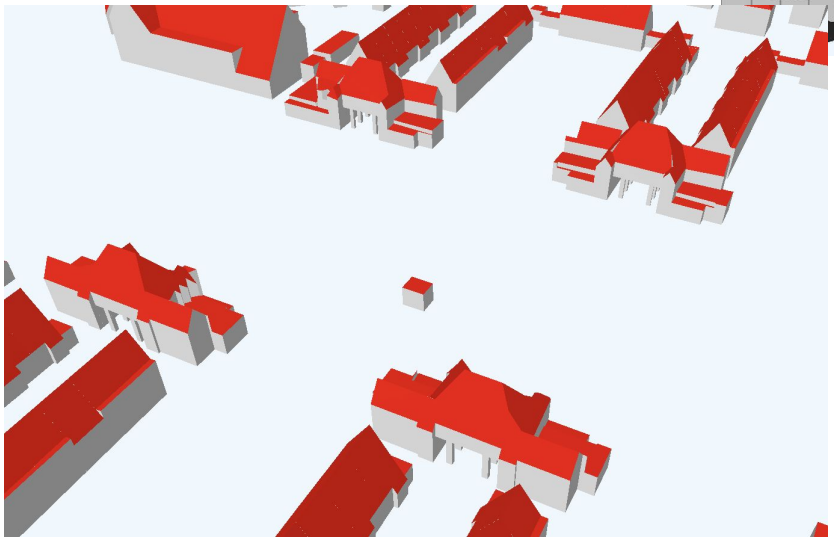






3D model resultaat





Current activities

- Trying to get more oblique imagery with good interior/exterior parameters
- Scale up to larger areas + iterative improvements
- Improve geometric validity of 3DBAG models

Innovatiebudget 2026

Projectplan Innovatiebudget 2026

- **‘slim-actualiseren**’ van 3DBAG, recentere en rijkerer 3D-gebouwmodellen door gebruik aanvullende gegevensbronnen + innovatieve algoritmes
- **Proof-of-concept-implementaties**, die de weg vrijmaken voor een toekomstige integratie in het 3DBAG-productieproces

Projectplan Innovatiebudget 2026

1. Verbeterde actualiteit door gebruik alternatieve bronnen
   Op basis van data contributies door bv gemeentes

2. Verbeterd detail door puntenwolkfusie

3. Versiegeschiedenis op basis van mutatiedetectie
   Maakt incrementele updates mogelijk

4. ‘Tijdreizen’: bekijk historische staat bebouwing
   (waar data beschikbaar is)

5. Visualisatie in vernieuwde 3D-viewer

Netherlands Enterprise Agency

Ministry of Housing and Spatial Planning

kadaster

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

hetWaterschapshuis

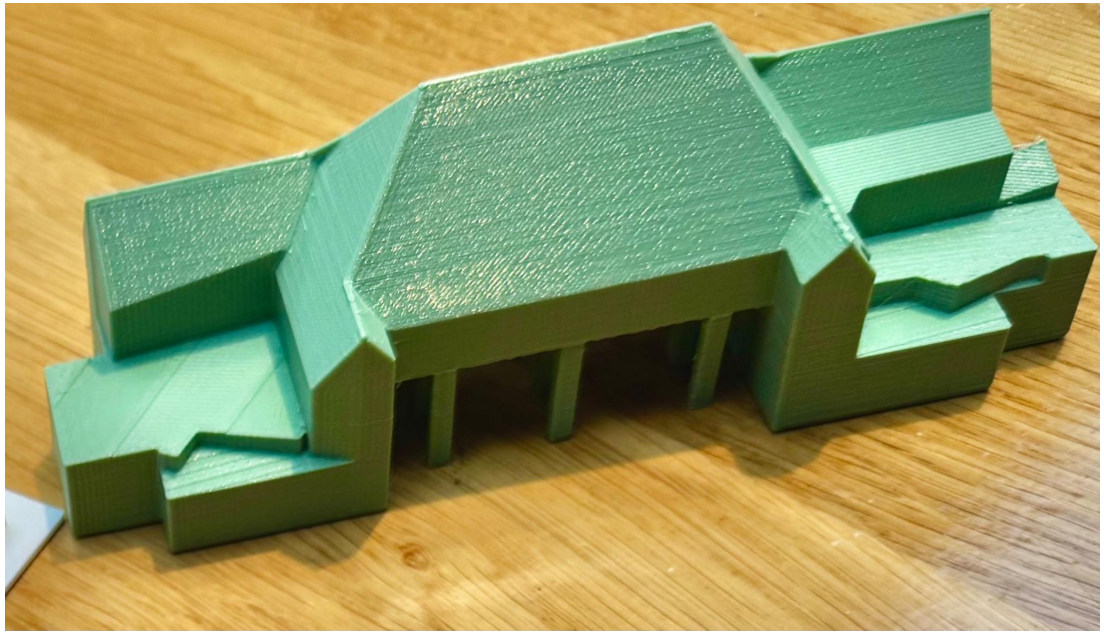
Gemeente Amsterdam

Gemeente Utrecht

GEONOVUM

Innovatieve algoritmes voor betrouwbare, stedelijke 3D-modellen

Update, 11 mei 2026
Online

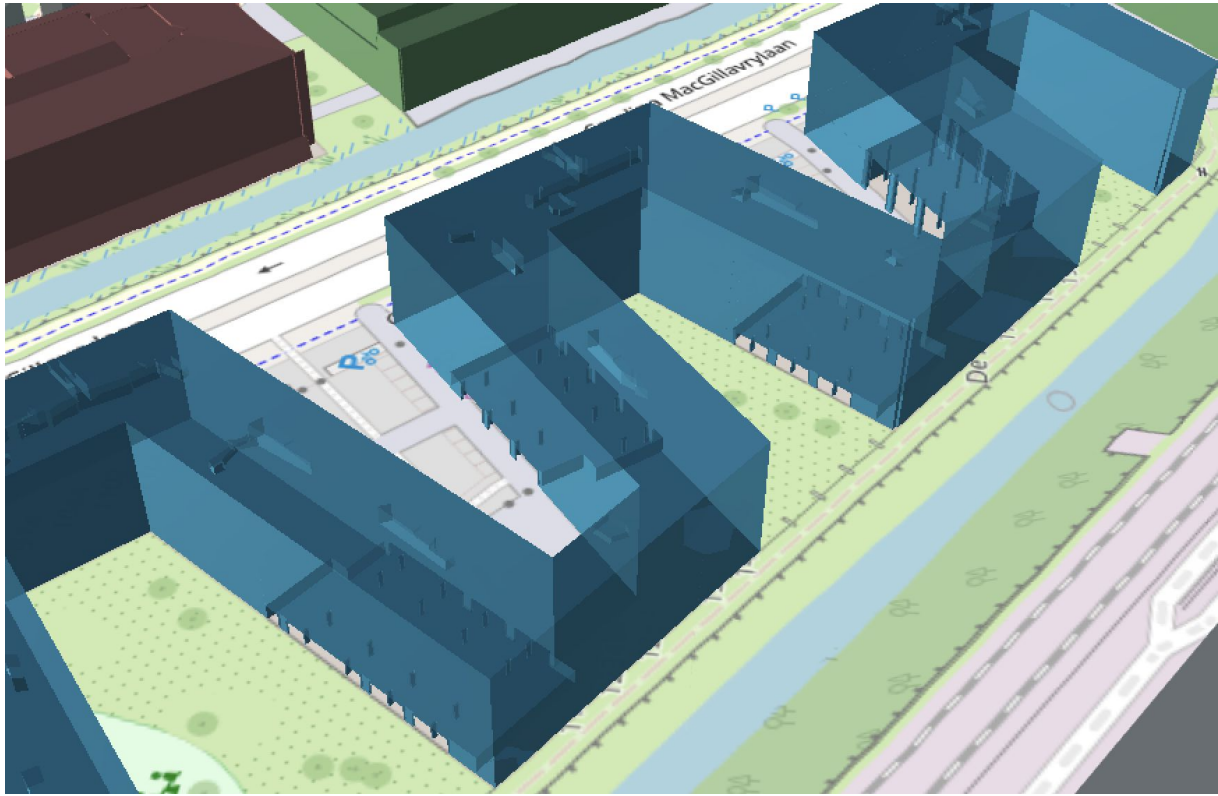


3DGI

TU Delft 3Dgeoinfo

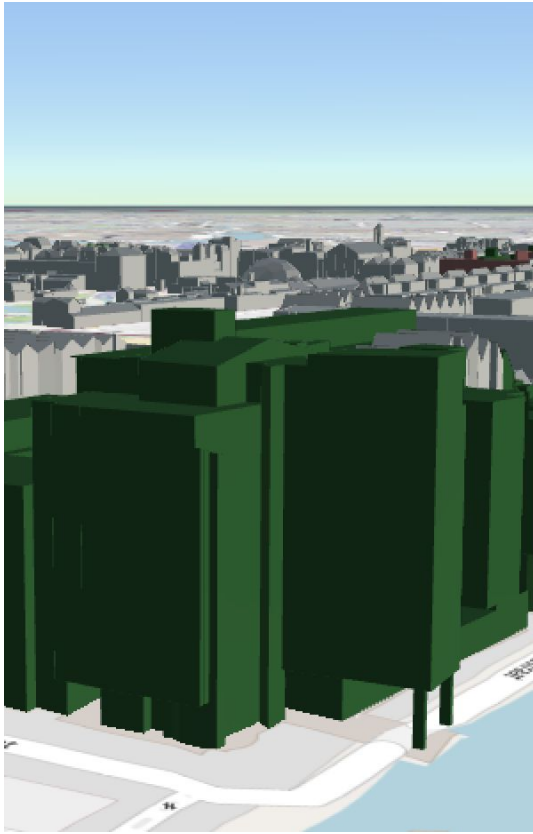
Inhoud

1. Status update
2. Demo
3. Over de hoogtebronnen
4. Volgende stappen
5. Volgende 3DBAG release



Status update

- ✓ Detectie + reconstructie onderdoorgangen voor heel NL
- ✓ Hoogte uit streetlidar voor heel Amsterdam
  - Met dank aan Wietse voor de data!
- ✓ Stage Juan voltooid (hoogte uit obliek)
- ✓ Implement border extension for 2D underpass polygons
- ✓ Algemene verbeteringen 2D + 3D delen van de pijplijn
- ✓ 1ste iteratie verbeteringen op basis van nationale run



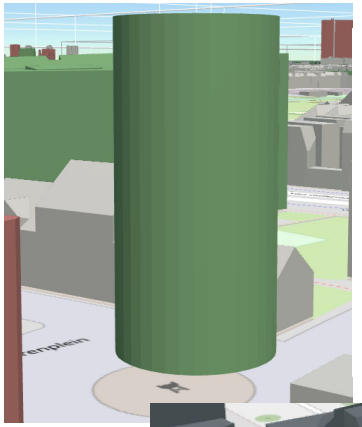
Demo

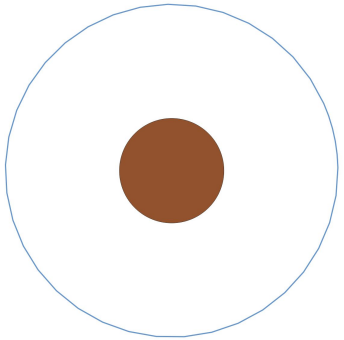
Voorlopige bevindingen

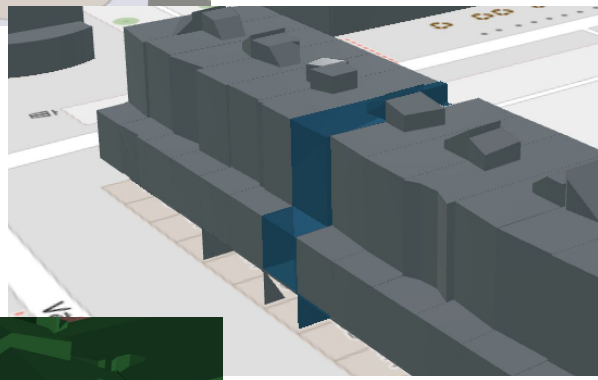
Type fouten:

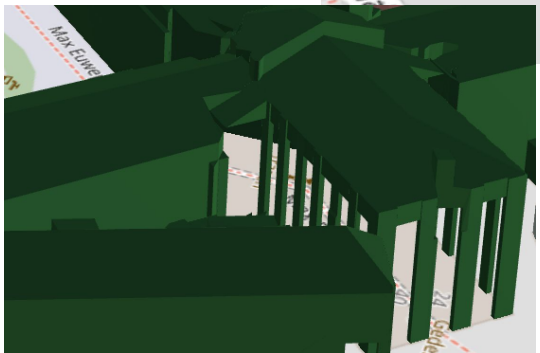
1. Geometrische verwerking 2D polygoon
   a. Ontbrekende pilaren
   b. Bepaling + extrusie van ‘open’ zijden
2. Geometrische validiteit 3DBAG modellen
   a. Rode gebouwen in demo
   b. Dit was voorzien in het voorstel
3. Hoogtebepaling uit straatlidar
   a. Hoogte soms te hoog of te laag
   b. Soms te weinig punten

Type 1, is reeds grotendeels gerepareerd.



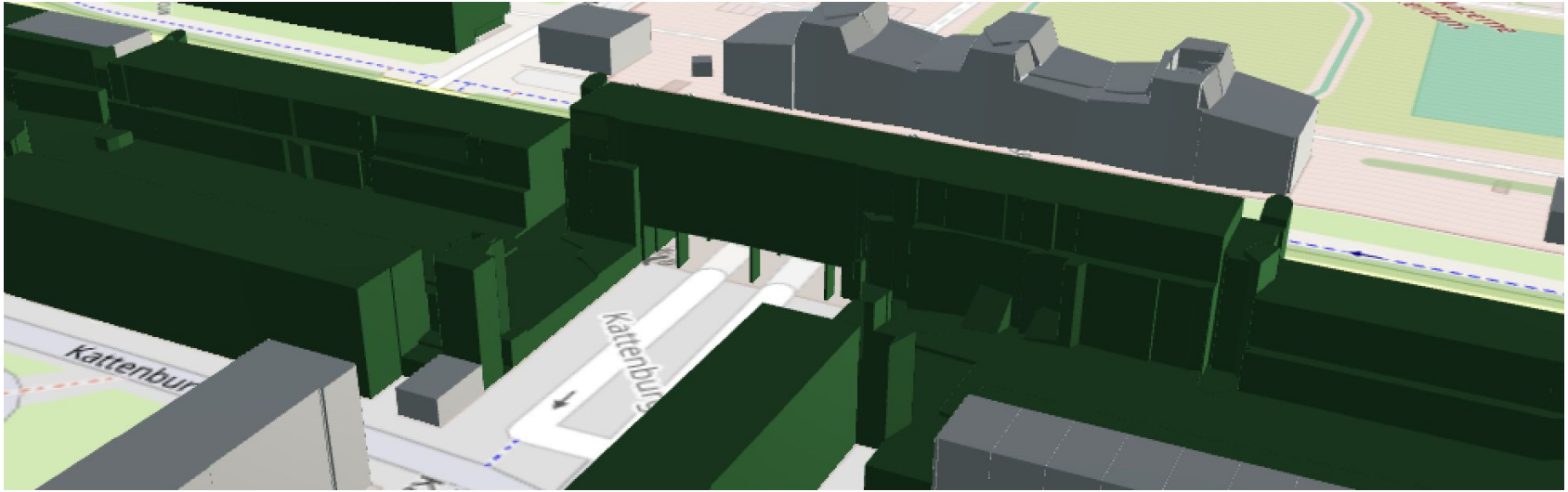




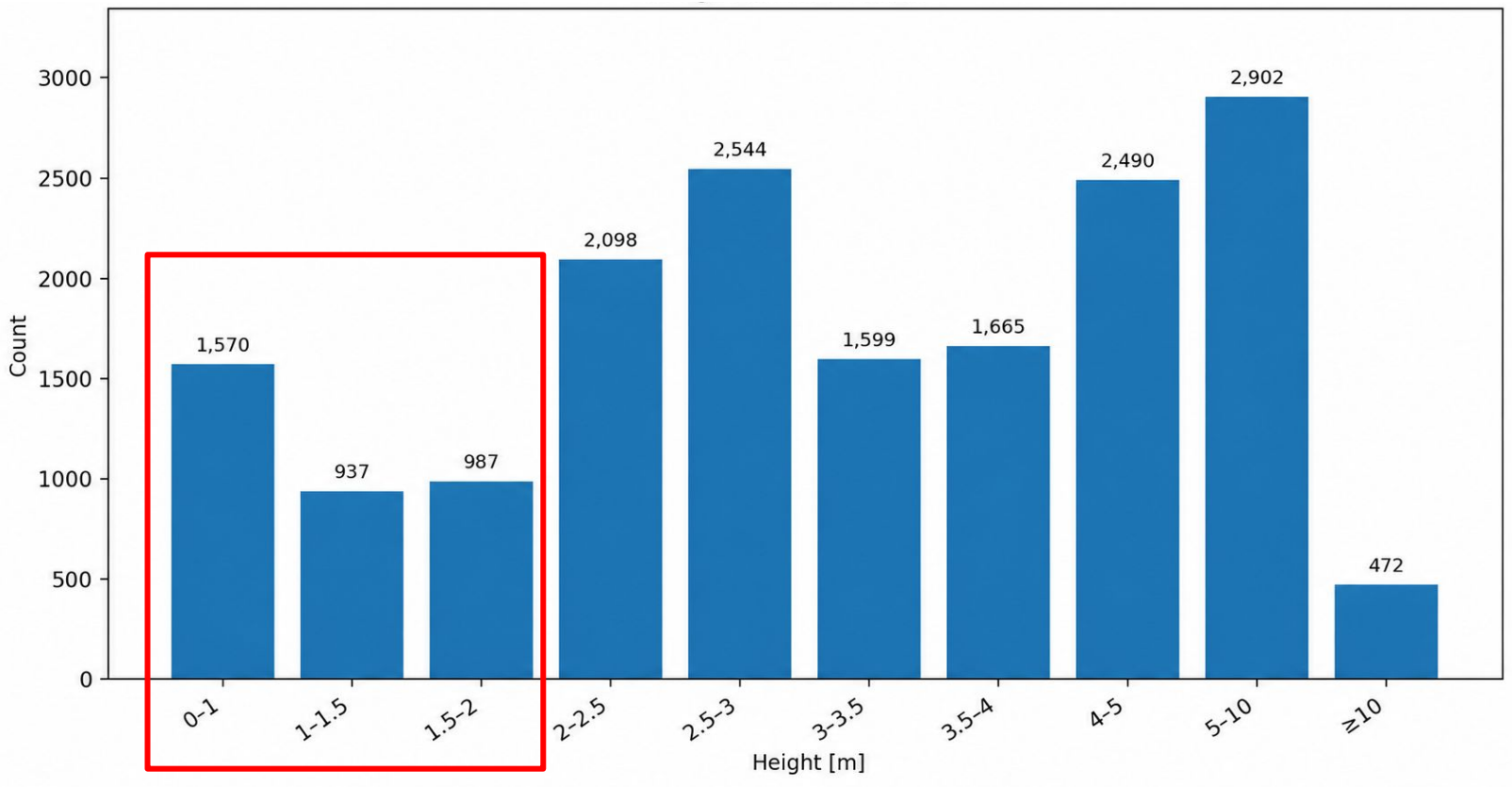


Hoogtebepaling uit streetlidar

- Met de Amsterdam data hebben we een heel mooi demo gebied
  - Incl toestemming gebruik voor 3DBAG
- Onze methode is snel en draait goed op bestaande hardware
- Huidige resultaten zijn bemoedigend, goed genoeg voor integratie 3DBAG



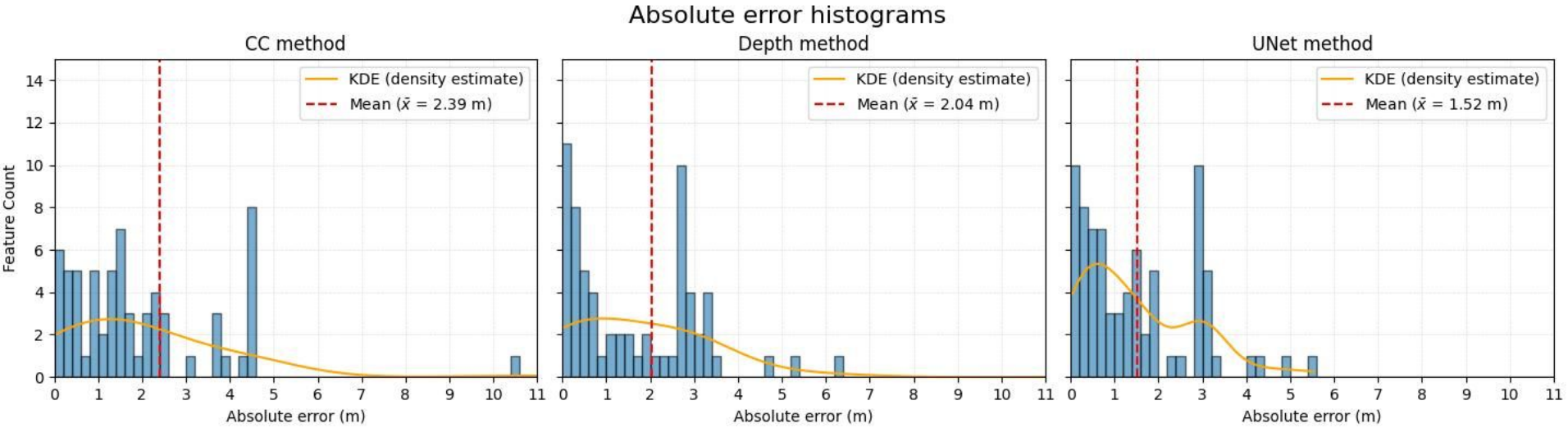
Hoogtes uit streetlidar (Amsterdam)



Hoogtebepaling uit oblieke beelden

- Stagair Juan heeft een mooi rapport opgeleverd
  - Vergelijking tussen 3 methodes, doorontwikkeling is nog nodig
  - Een interessante bevinding: 3D Rotterdam onderdoorgangen bevatten fouten

Na correctie 3D Rotterdam data



Hoogtebepaling uit oblieke beelden

- Methode is nog wel experimenteel + trager om te draaien
  - GPU Hardware is idealiter nodig
- Vereist hoge kwaliteit data (GSD + orientatie parameters)
- Data bronnen
  - Prorail heeft mooie open data, maar alleen rondom spoorwegen
  - Binnenkort (?): open data van HWH pilot Noord Nederland
  - Kavel10 heeft data opengesteld, maar is waarschijnlijk geen open data

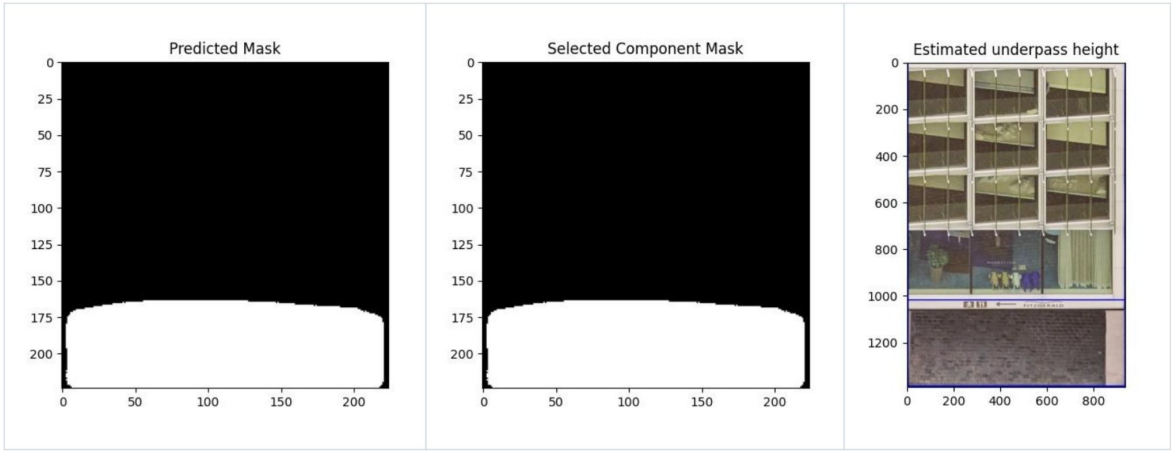
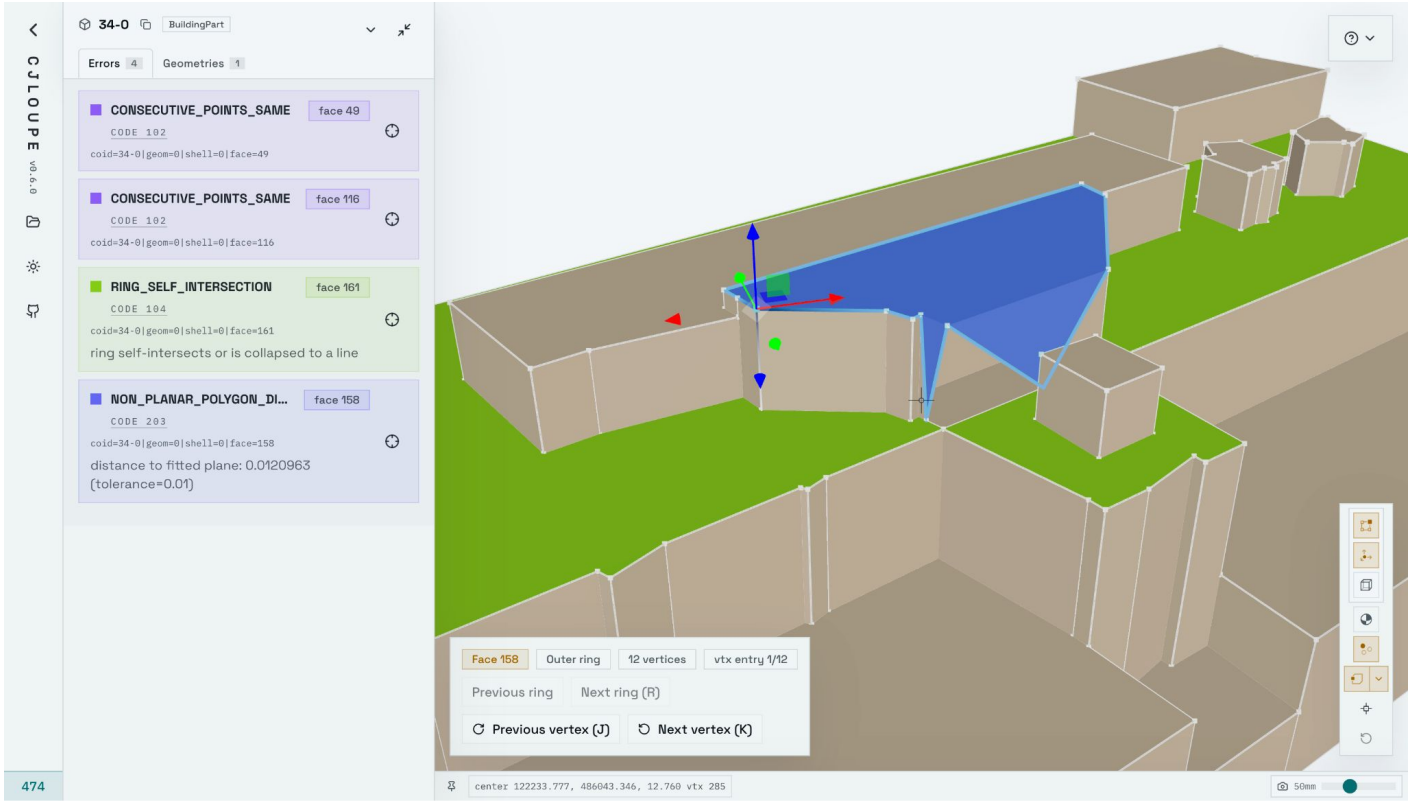


Figure 9. application of the U-Net model method.

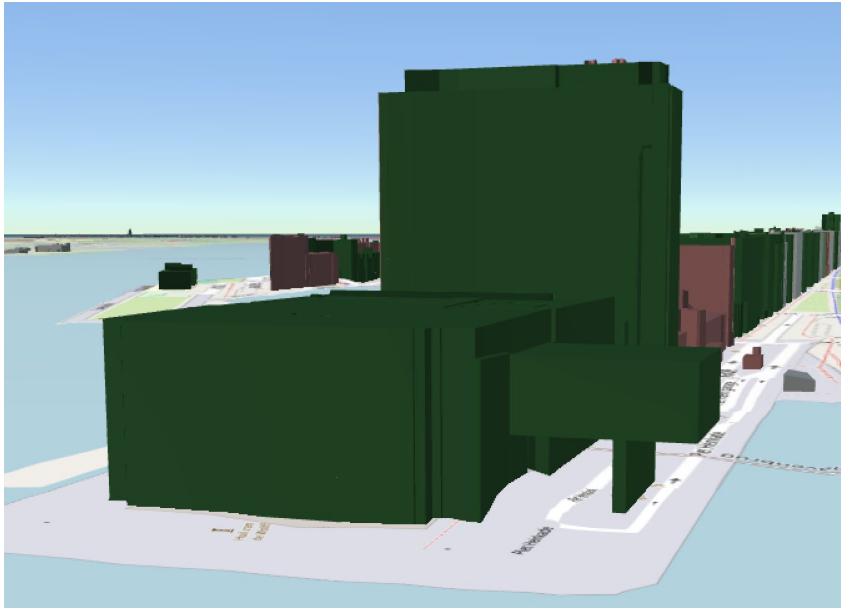
Verbeteren geometrische validiteit 3DBAG

Tussenstap: inspectie tool CityJSON geometrie (fouten op basis val3dity)

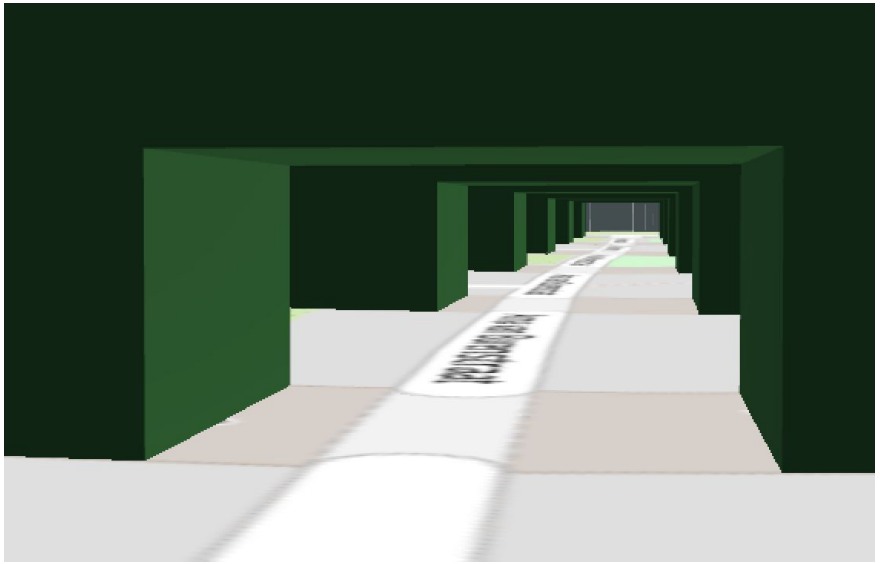


Volgende stappen

- Voorkomen van geometrische fouten in 3DBAG modellen
- Handmatige inspectie/validatie correctheid streetlidar hoogtes
- Iteratieve bug fixing
  - We zullen regelmatig de demo website updaten
  - We staan ook open voor feedback
- Integratie in 3DBAG pipeline



Volgende 3DBAG versie



- Huidige resultaten onderdoorgangen reeds beschikbaar als PoC
- Binnen innovatie project ook integratie in 3DBAG generatie pijplijn
- Meer werk dan voorzien voor integratie streetlidar data (Amsterdam)
- Voor ‘officiele’ nieuwe 3DBAG release zou ook mooi zijn:
  - Update op basis AHN6
  - Update van model voor schatting # bouwlagen
  - Bugs repareren
  - Algemene 3DBAG software verbeteringen en onderhoud
- Geschat budget hiervoor: 150 uren extra , ~22K