

3D geoinformation

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

cyclomedia

Semantic Understanding of Urban Scenes from Textured Meshes

GEO 1016: Photogrammetry and 3D Computer Vision

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 TU Delft



Self-introduction



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University of Technology

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About Me

I am a Postdoctoral Researcher in the [Laboratory of Geo-information Science and Remote Sensing](#) at Wageningen University & Research, and remain affiliated with the [3D Geoinformation group](#) at Delft University of Technology (TU Delft) as a visiting researcher. I earned my PhD from TU Delft, where my research focused on the semantic understanding of urban scenes using textured meshes. Previously, I completed dual Master's degrees in Geoinformation Science from [Technische Universität Berlin \(TU Berlin\)](#) and [The Chinese University of Hong Kong \(CUHK\)](#).

My expertise spans photogrammetry, computer vision, computational geometry, geoinformation, and remote sensing. My research aims to advance the interpretation of urban environments through enhanced 3D modeling techniques and to develop innovative applications that leverage 3D spatial intelligence.

Research Interests

- **Photogrammetry and Computer Vision:** 3D reconstruction, semantic understanding, human-computer interaction, and shape analysis
- **Computational Geometry:** geometry processing and analysis, with a focus on textured meshes and point clouds
- **3D Geoinformation:** data acquisition and integration, city modeling, urban scene analysis and simulation, and geodatabase

Outline

- 1. Fundamentals of urban 3D reconstruction**
- 2. Benchmarking object-level semantic segmentation**
- 3. Planarity-sensible semantic mesh segmentation**
- 4. Structure-aware interactive annotation**
- 5. Lightweight 3D city model reconstruction**
- 6. Future Research Prospects**
- 7. References**

An aerial view of a city with a 3D reconstruction overlay. The reconstruction is semi-transparent, showing yellow and blue building models and green tree models over the real-world scene. The city features a river, a curved road, and various buildings. The text "1. Fundamentals of urban 3D reconstruction" is centered over the image.

1. Fundamentals of urban 3D reconstruction

3D Data Acquisition – **Sensors & Platforms**



Camera



LiDAR



Submarine / Boat



Tripod



Vehicle



Drone



Aircraft



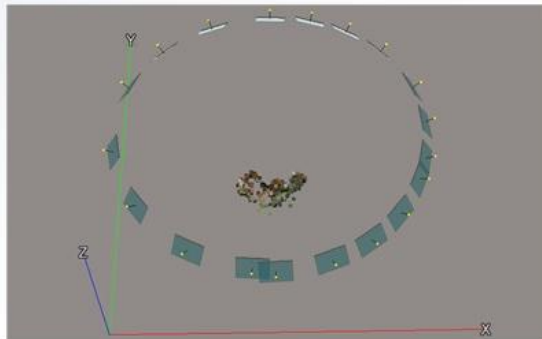
Satellite

3D Data Processing – From Camera

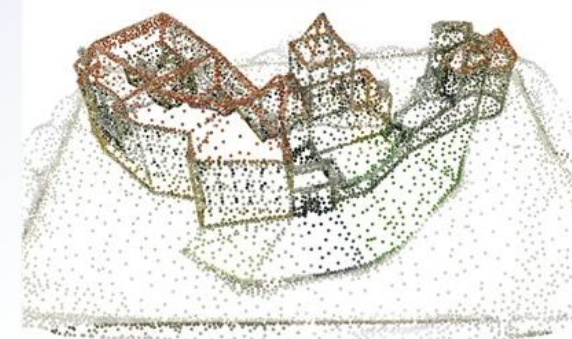
Multiple Views Images



Multiple View Geometry



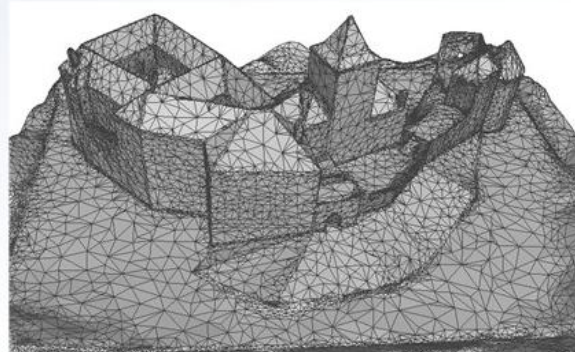
Sparse Point Cloud



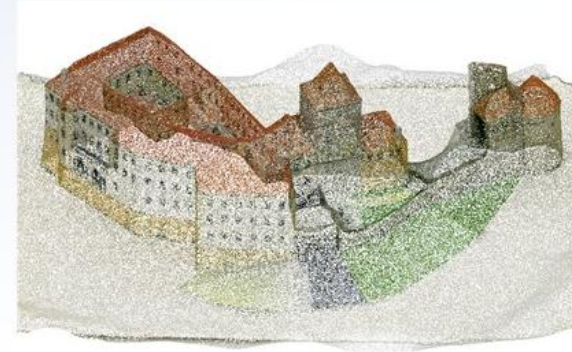
Textured Mesh



Triangulated Mesh

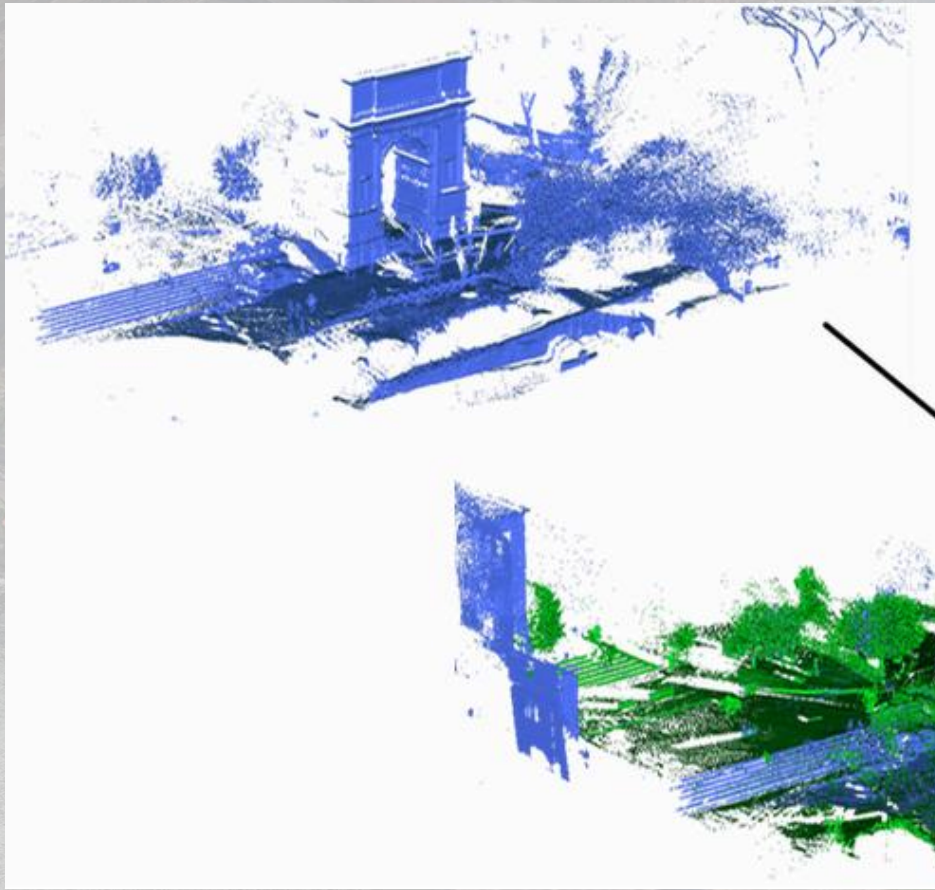


Dense Point Cloud

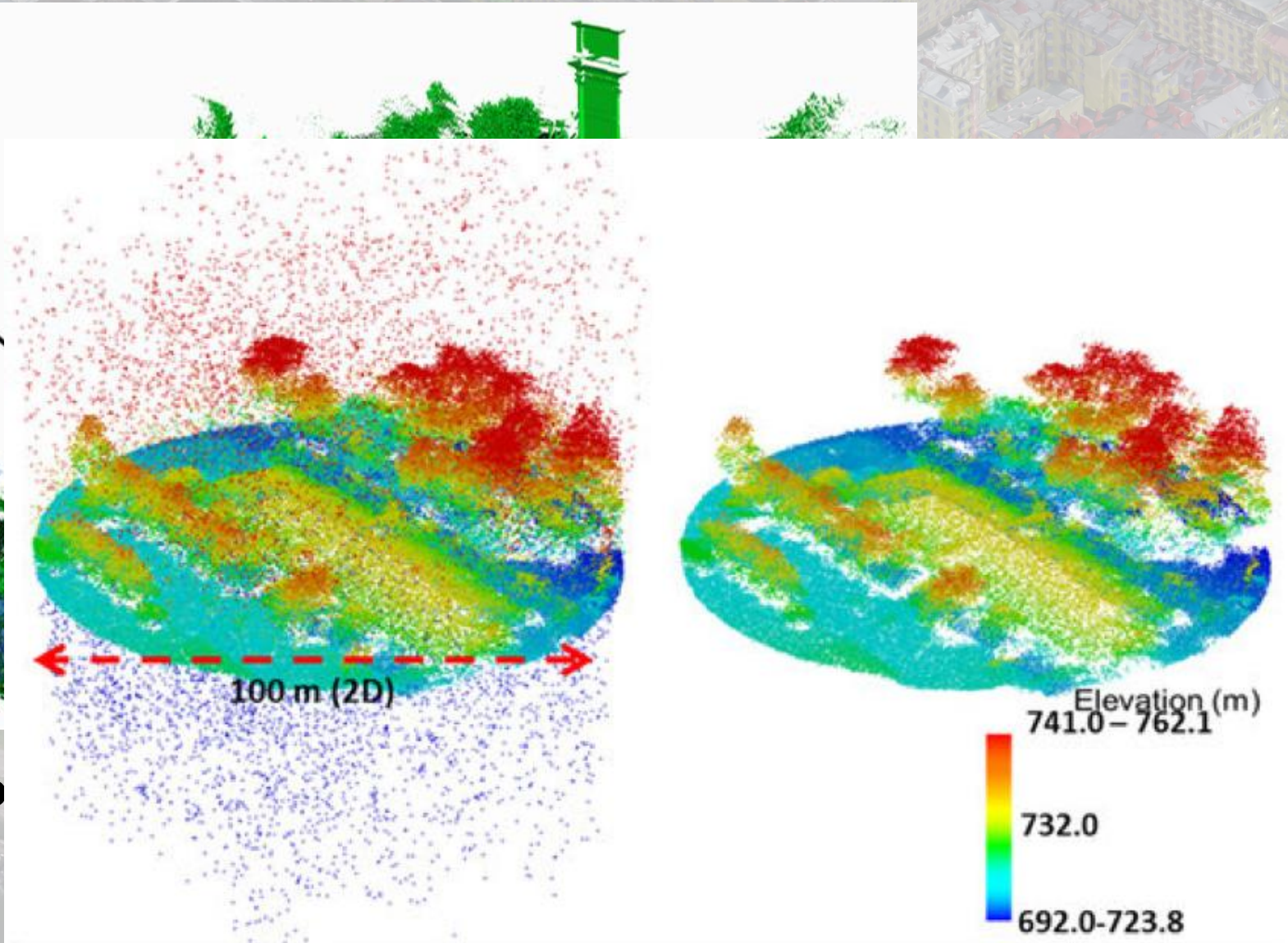


3D Reconstruction Pipeline

3D Data Processing – From LiDAR



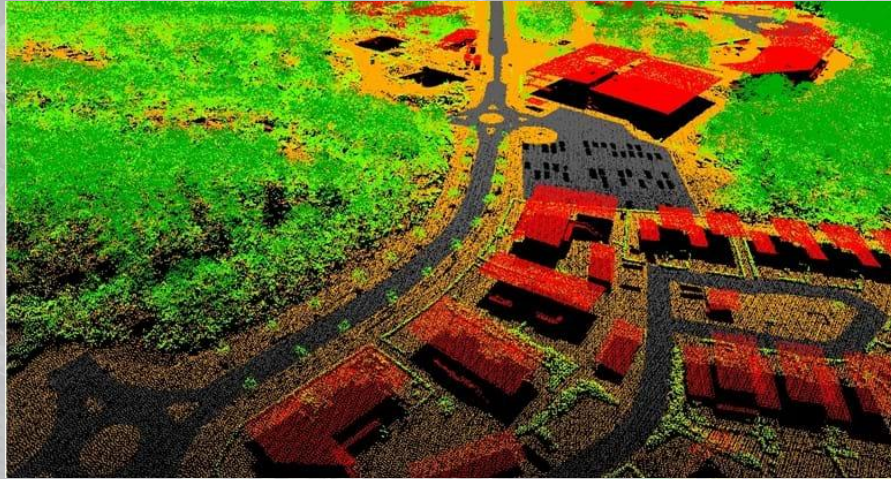
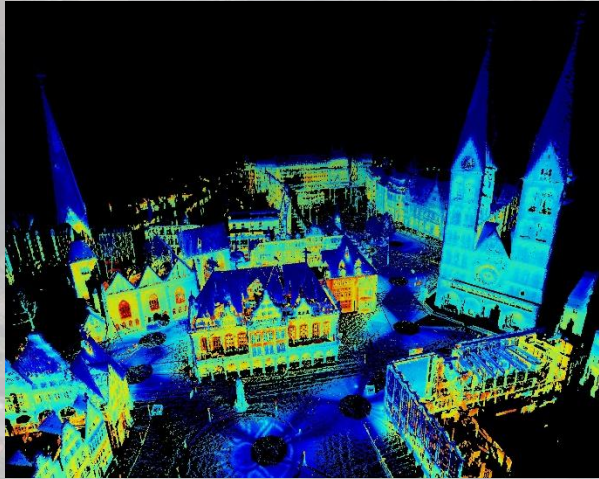
Point Cloud



Point Cloud Denoising

3D Representations of Urban Scenes

Point Clouds, Textured Meshes, Polygonal Surface Model (with/without textures)



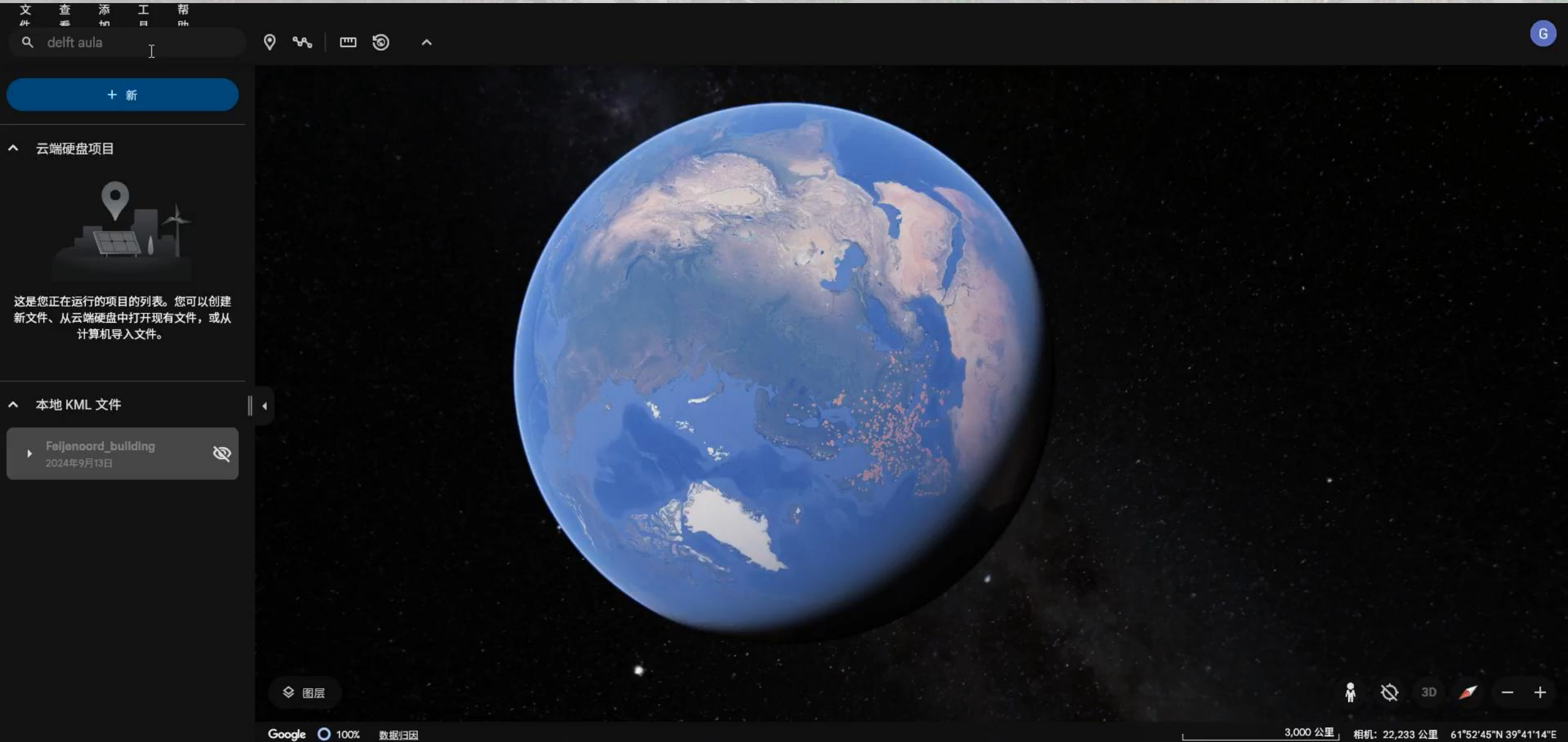
3D Representations of Urban Scenes

Nerf: Neural Radiance Fields

3DGS: 3D Gaussian Splatting



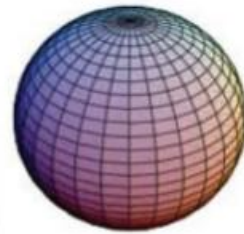
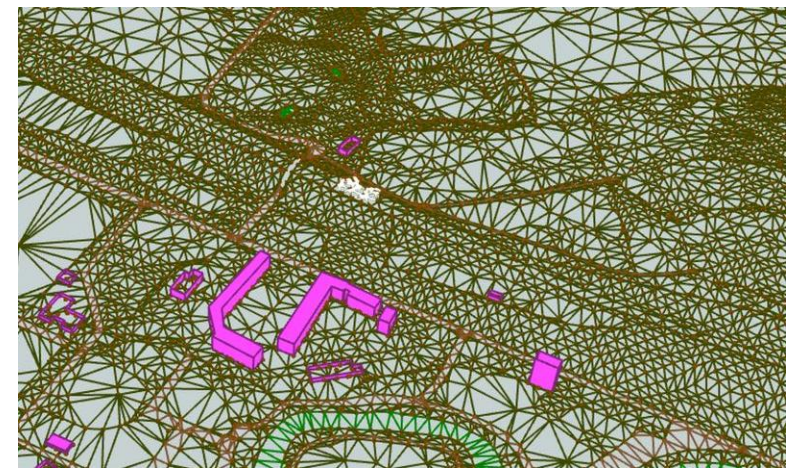
Google Earth's Photorealistic Mesh covering more than **2,500** cities worldwide



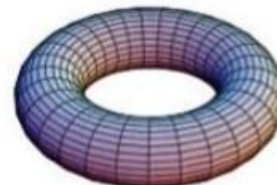
Why using Textured Meshes ?

Advantages of using the textured meshes:

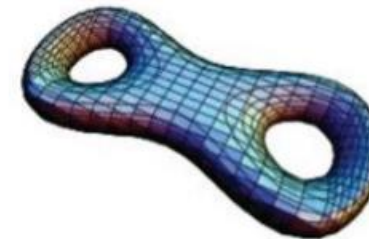
- Adaptive representations.
- Efficient rendering.
- Rich texture color information.
- Topological information.



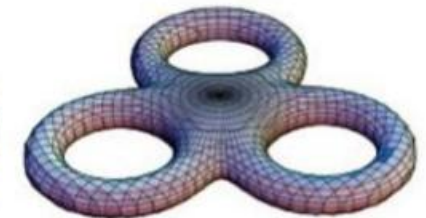
Genus 0



Genus 1



Genus 2

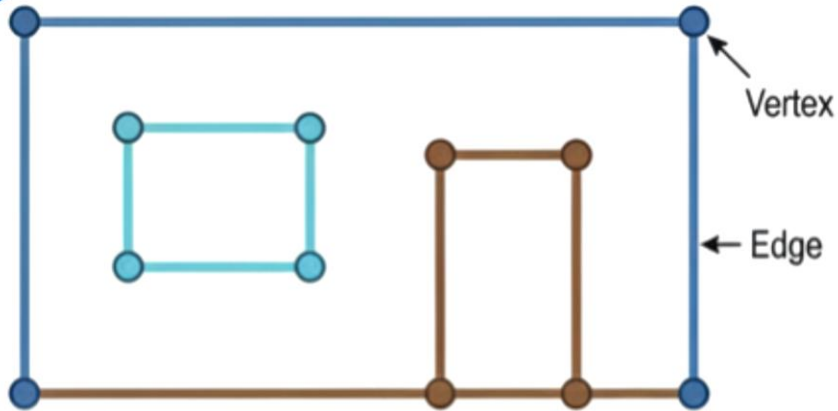


Genus 3

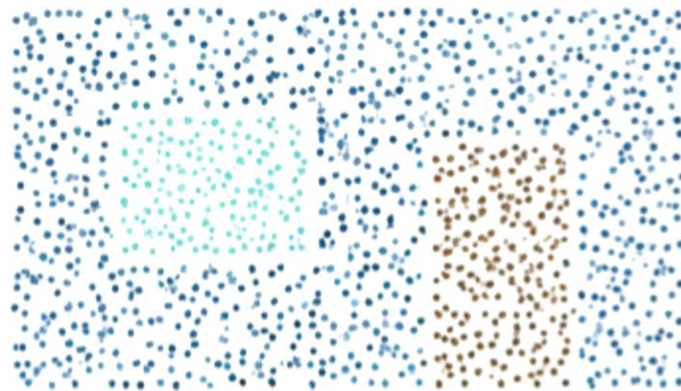
An aerial view of a city with a 3D model overlay. The model consists of yellow buildings, green trees, and pink/purple parking spaces. The city is situated near a body of water with a curved road and a parking lot. The background is a faded, semi-transparent image of the same city.

Which 3D representation is best suited for spatial computation in urban scenes?

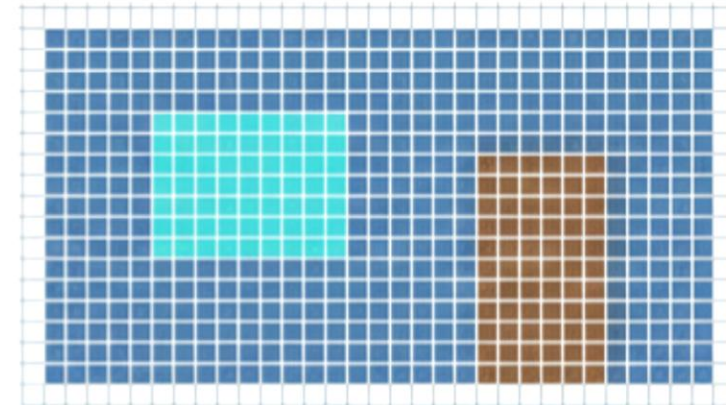
3D Representation for Spatial Computation



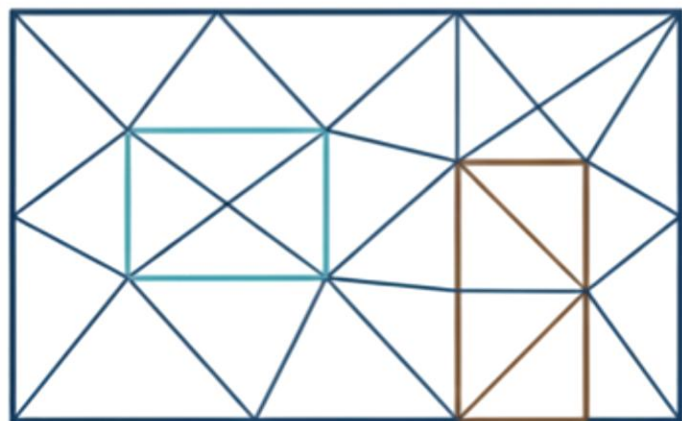
1. VECTOR REPRESENTATION (Vertices & Edges)
Defined by explicit geometric primitives.



2. POINT CLOUD
Unstructured set of discrete data points.



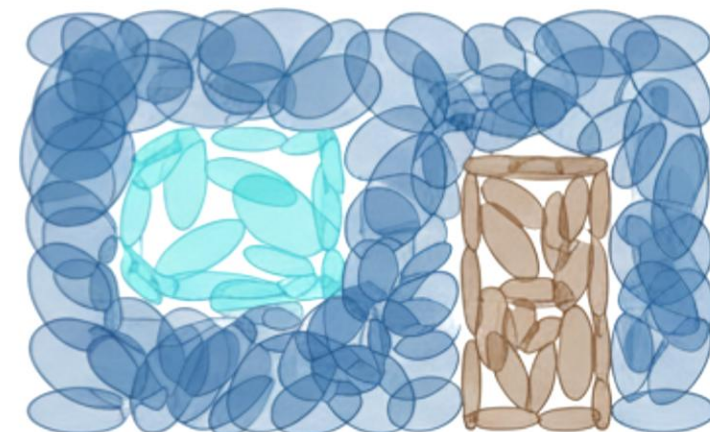
3. VOXEL GRID (2D Slice)
Volumetric elements on a regular grid.



4. TRIANGLE MESH



5. NEURAL RADIANCE FIELDS (NeRF Slice)



6. GAUSSIAN SPLATTING (2D Ellipses)

Semantic 3D city models (CityGML)

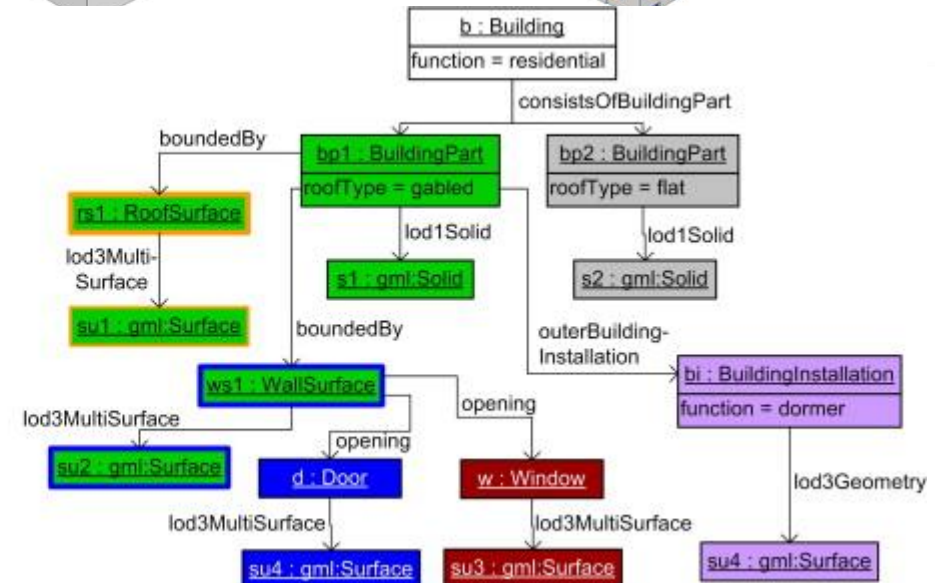
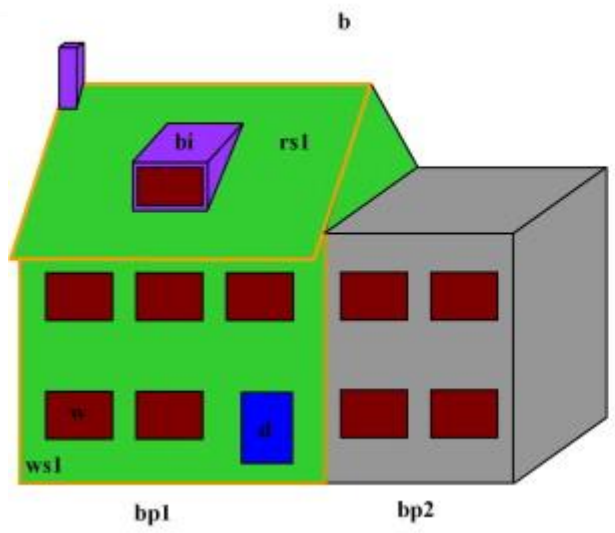
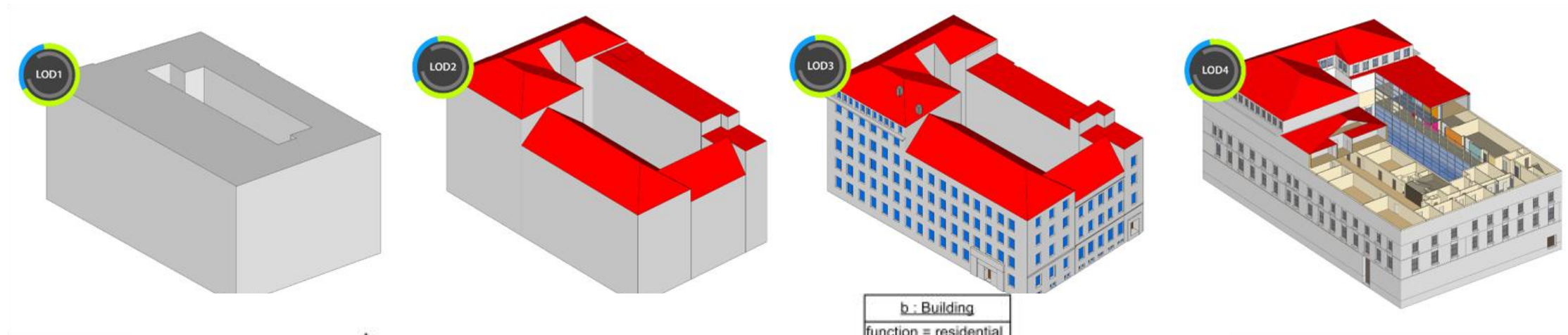
Données cadastrales

Maquette de ville numérique

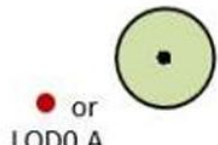










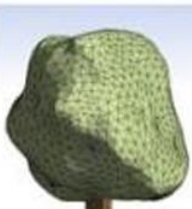
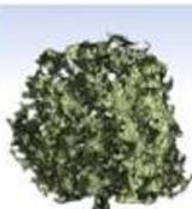

BIM

QUARTIERS EXISTANTS

Disponibilité et résolution des données



Semantic 3D city models

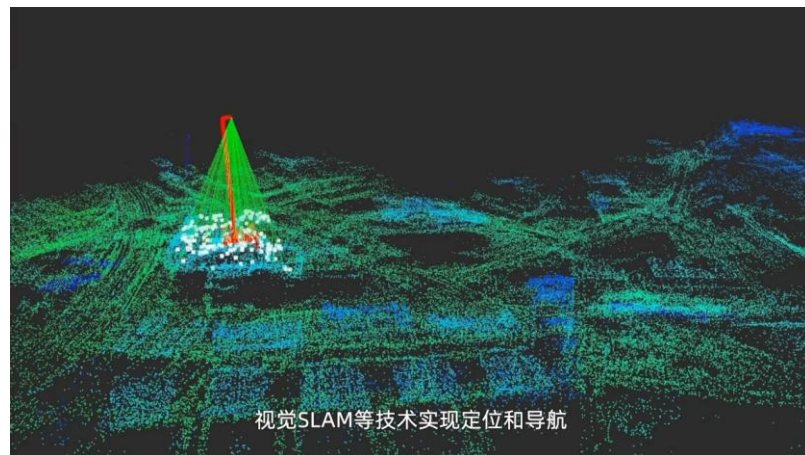
	LODx.A	LODx.B	LODx.C	LODx.D
LOD0.x	 LOD0.A	 LOD0.B	 LOD0.C	
LOD1.x	 LOD1.A	 LOD1.B	 LOD1.C	 LOD1.D
LOD2.x	 LOD2.A	 LOD2.B	 LOD2.C	Separate crown
LOD3.x	 LOD3.A	 LOD3.B	 LOD3.C	 LOD3.D



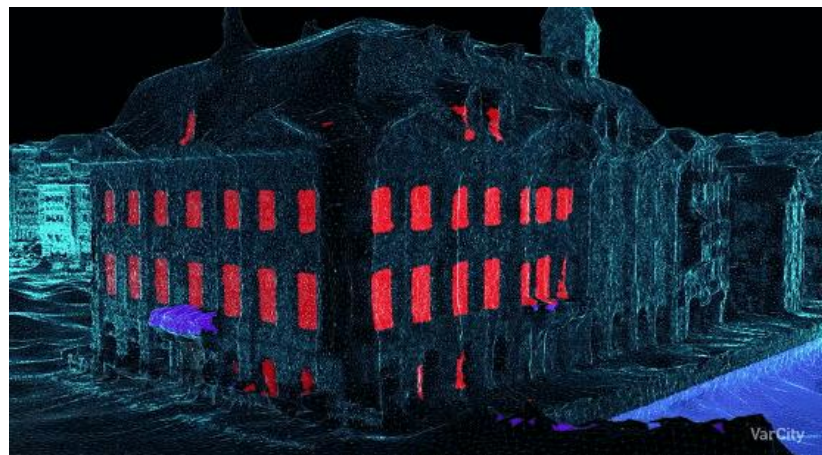
Applications of 3D urban meshes (CityGML)

- **Requirements:** Semantic information for interpretability, simplified geometry for computation.

Urban Low-Altitude Logistics Delivery



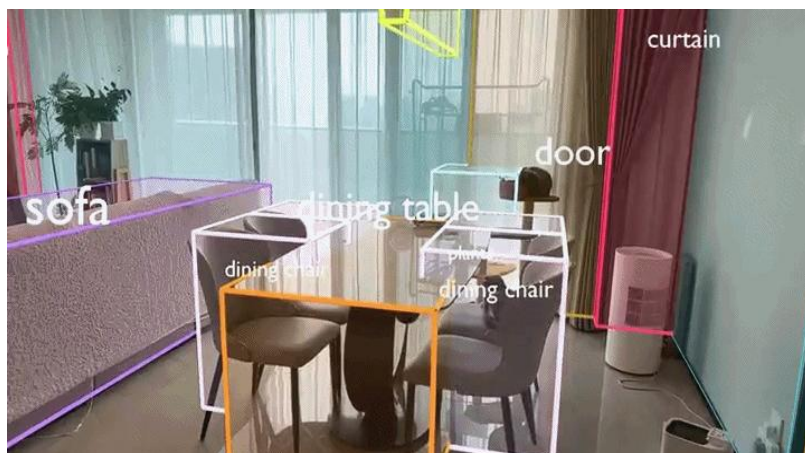
Precise Urban 3D Mapping



Urban Environment Simulation



Indoor 3D Scene Modeling



Metaverse and Spatial Intelligence



Embodied AI Simulation Training



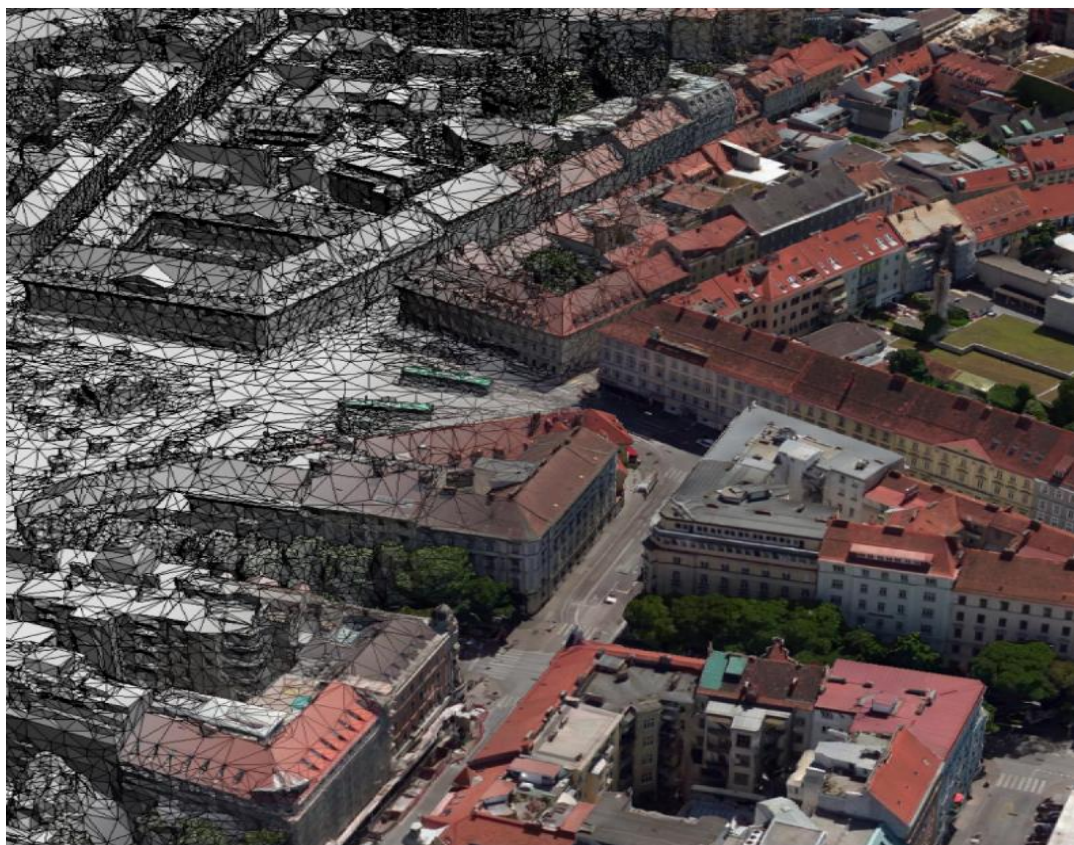
From Visualization to Computation



Reality: Textured Meshes Are Visually Perfect

Industry standard for visualization. Lightweight and visually realistic with continuous topology.

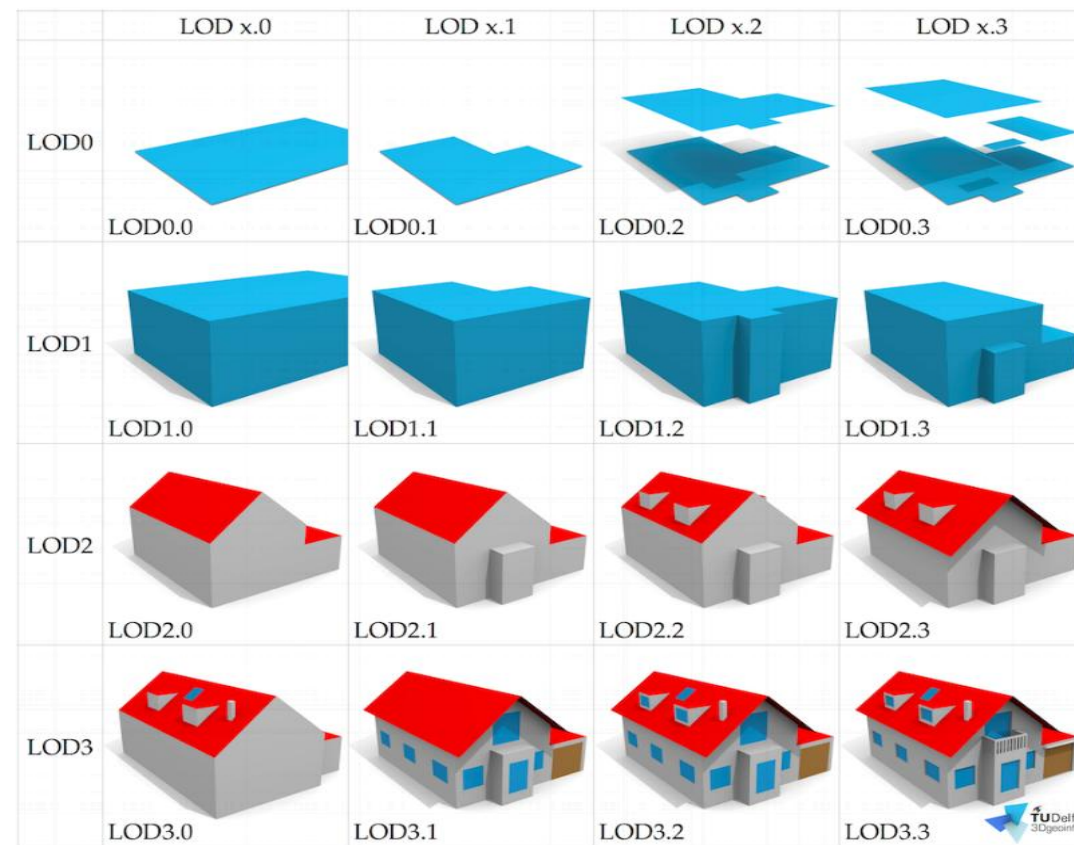
3D "Raster" Data



Bottleneck: Semantically Empty & Structurally Loose

Lack of structural information limits deep applications (Prediction, Simulation, Decision).

3D "Vector" Data



Scientific Challenges

Research Question: How to transform **visually realistic but unstructured** textured meshes into **computable, semantic, and topologically** guaranteed 3D city models?

Data & Tool Deficit

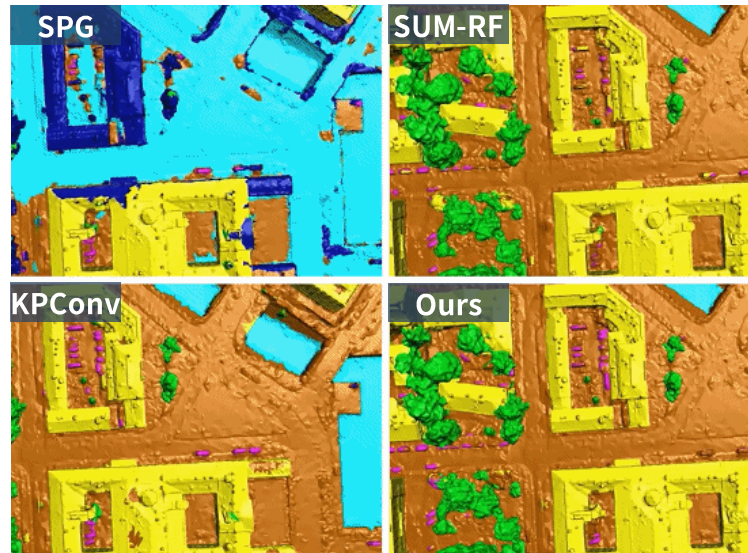
- Lack of mesh annotation tools
- Lack of benchmark datasets



Inefficient Annotation & Bottlenecks
Model Training and Evaluation

Semantic Segmentation Bottleneck

- Methodological gap
- Poor generalization



Fails in Large-Scale, Diverse and
Complex Urban Scenes


Structural Reconstruction Limits

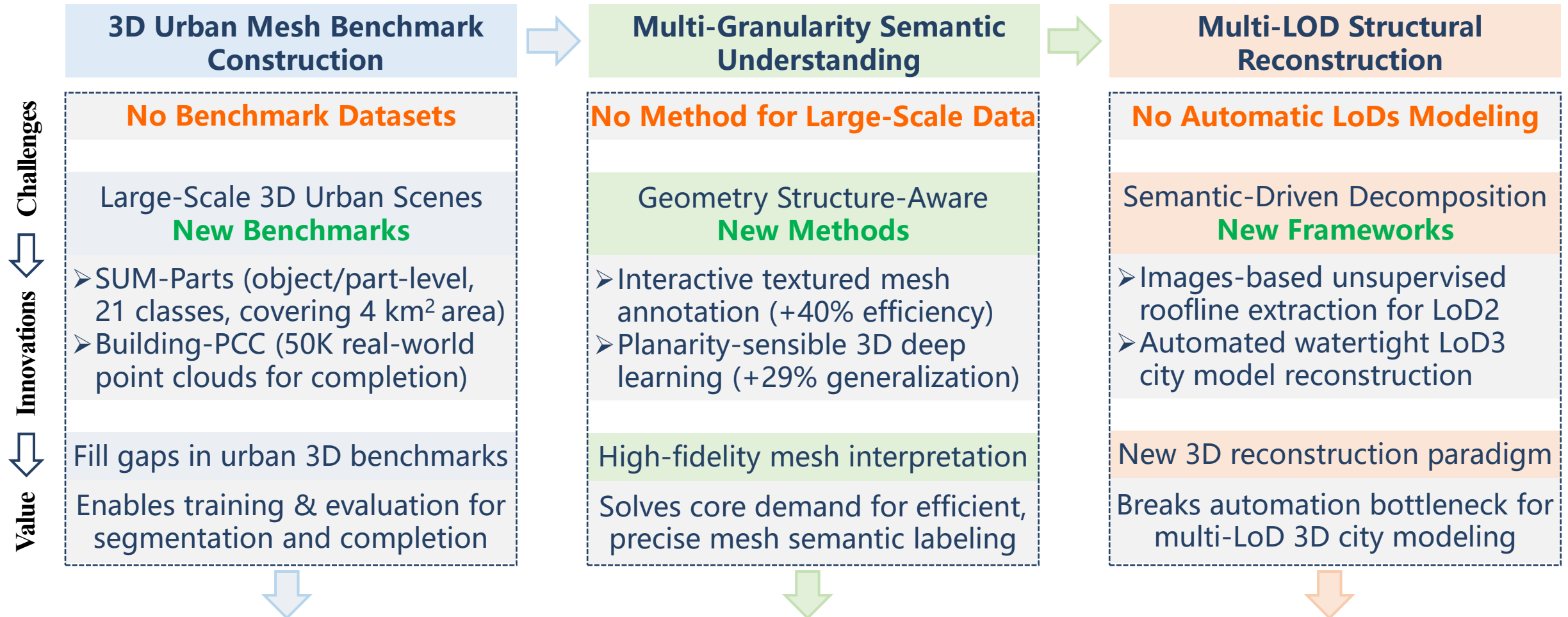
- Manual dependency
- Topological failures & No semantic



Prevents Automated LoD3 Semantic
City Model Reconstruction

Core Scientific Innovations

 **Core Objective:** To achieve high-fidelity semantic understanding and automated structural reconstruction from large-scale urban textured meshes.



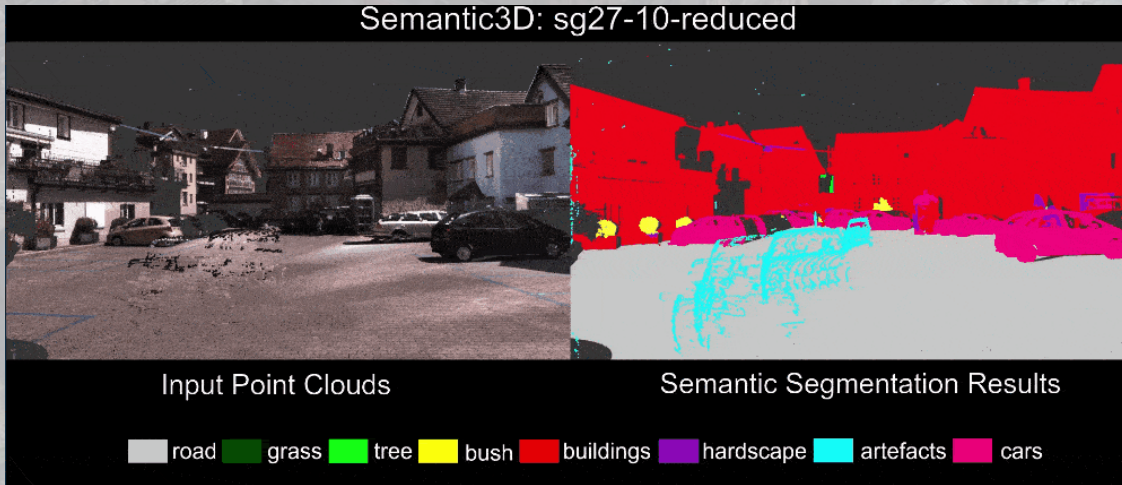
Urban Scene Multi-Granularity Semantic Understanding and Multi-LoD Solid Model Reconstruction¹⁹

An aerial view of a city with 3D semantic segmentation overlays. The buildings are colored in yellow and blue, trees in green, and roads in grey. The scene is viewed from an elevated perspective, showing a large building complex in the center-right, surrounded by other buildings and a waterfront area with a road and water. The text "2. Benchmarking object-level semantic segmentation" is overlaid in the center of the image.

2. Benchmarking object-level semantic segmentation

Semantic Understanding from Point Clouds

Semantic3D: sg27-10-reduced

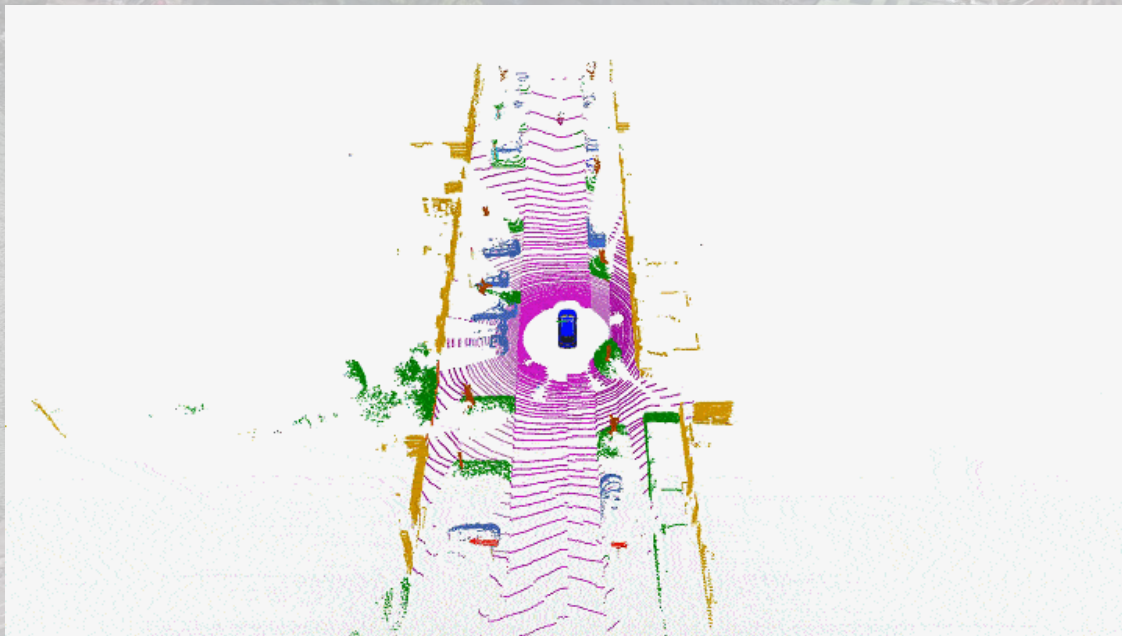


Semantic3D

Urban-Scale Point Clouds in SenseUrban Dataset (Birmingham)



SensatUrban

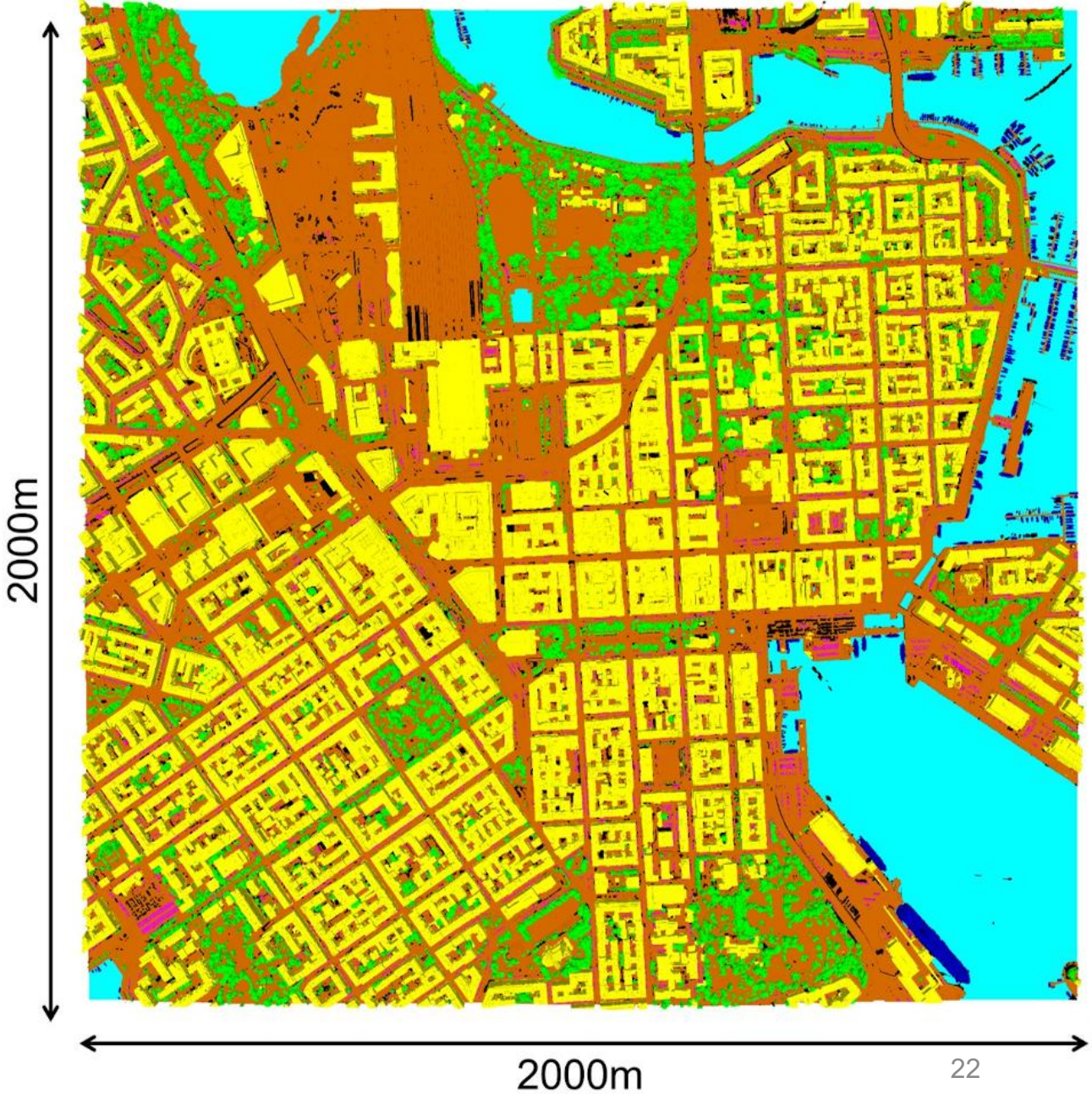
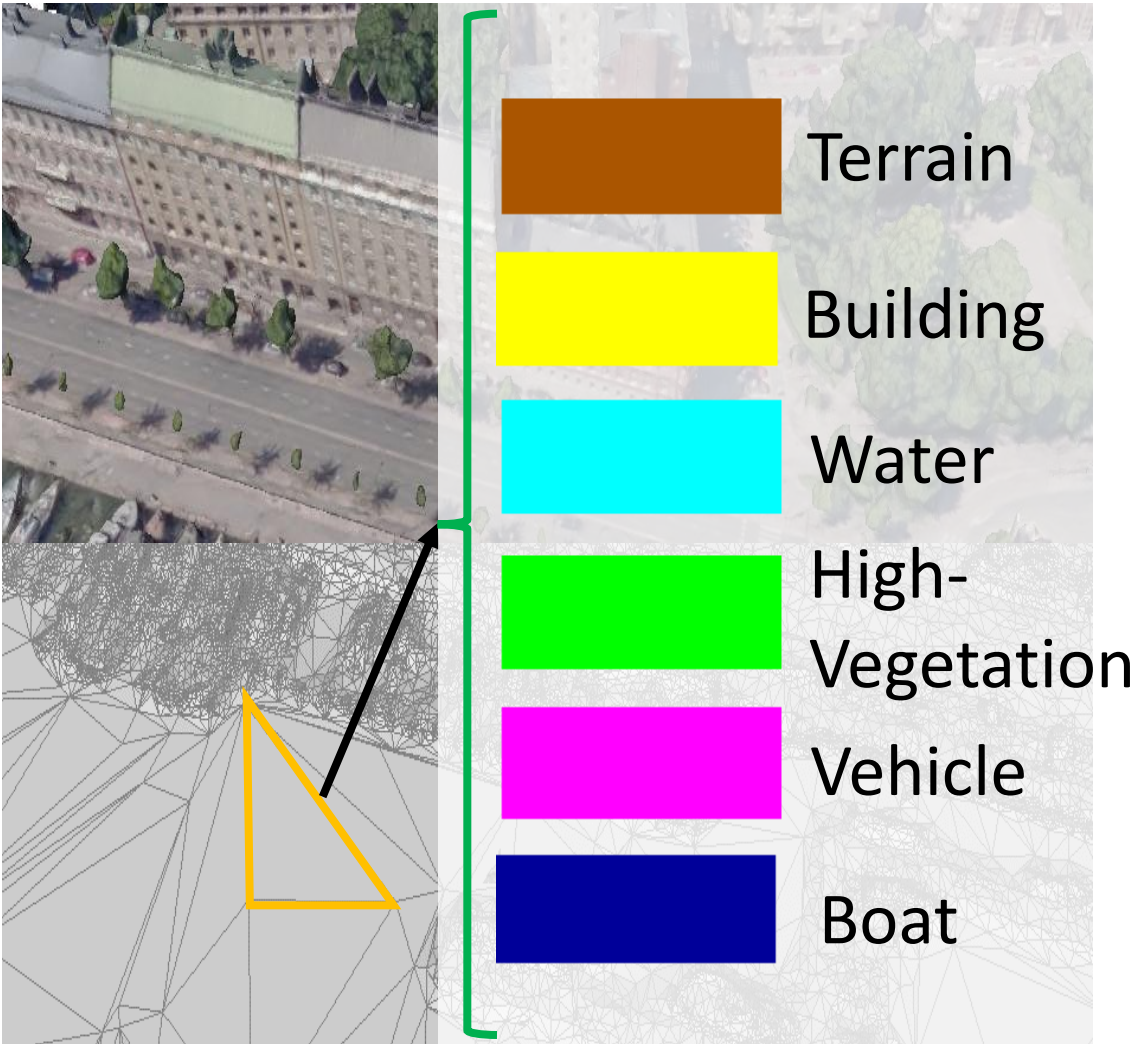


SemanticKITTI

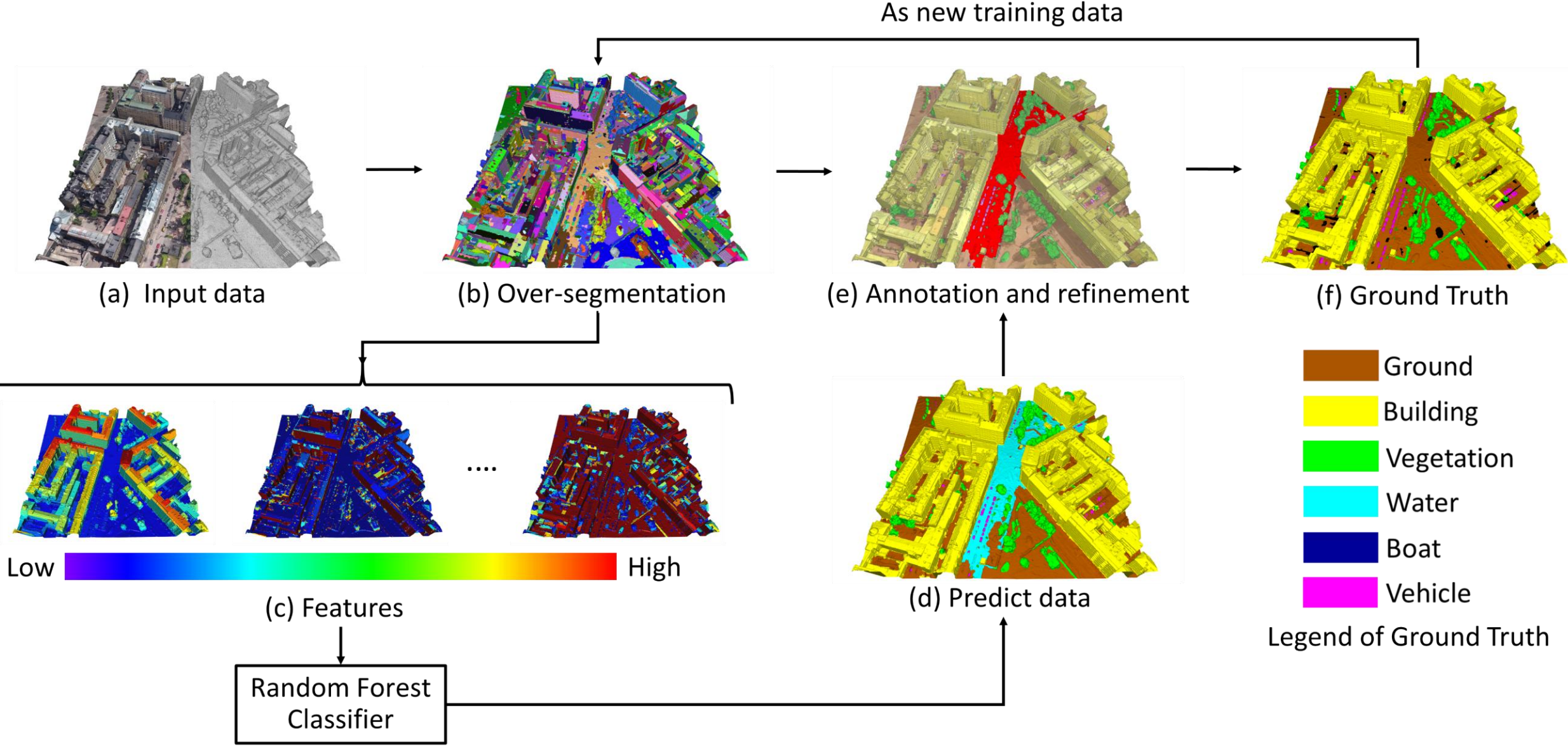


Hessigheim 3D

2. Methodology – Objective



2. Methodology – Pipeline



2. Methodology – Annotate the raw mesh

The screenshot displays the UrbanMeshAnnotator software interface. On the left side, there are several control panels:

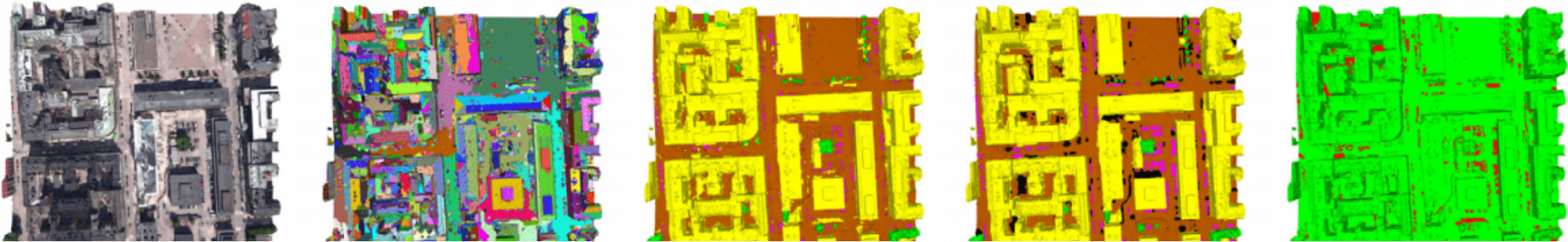
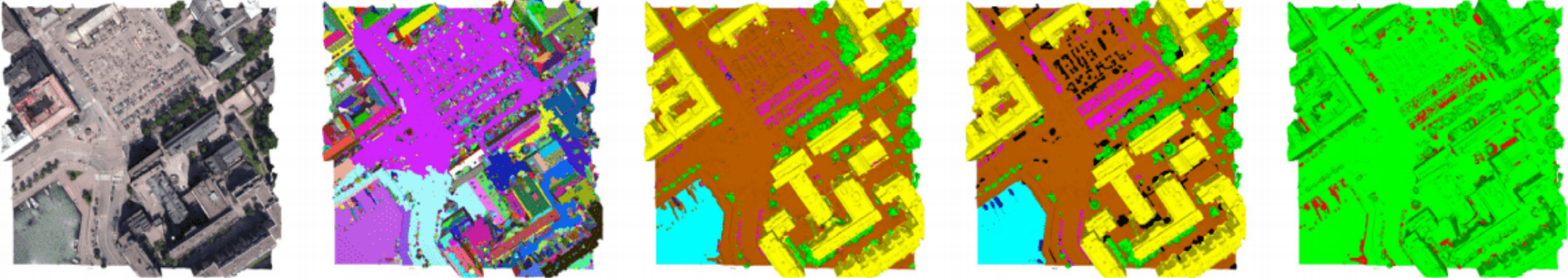
- Geometric Objects:** Shows a table with columns for Name, #, Mode, and View. The current object is 'Tile_+1987_+2...' with a blue square icon, 'TextureMode+flat+edges' mode, and a green checkmark in the View column.
- Annotation:** Includes a 'View' section with a 'Probability' dropdown set to 'below' and a slider at 100. Below this are 'Labels' for 'unclassified (U)', 'ground (G)', 'building (B)', 'vegetation (V)', 'vehicle (E)', and 'water (W)', each with a corresponding color swatch. An 'Estimated Progress' bar is at 0%.
- Surface Mesh Selection:** Features 'Selection mode' with 'Segments' selected. 'Smart mode' is set to 'Split entire mesh with region gro'. 'Basic selection' includes 'Multi-selection rings' (0), 'Expand/Reduce' (0), and 'Lasso' (unchecked). 'Extract the most planar region within a segment' has sliders for 'Max distance to plane' (0.70), 'Max accepted angle' (90.0), 'Min region size' (0), and 'K neighbors' (12). Buttons for 'Split' and 'Clear Segments' are present.
- Console:** Shows log messages: '[17:06:09] INFO: The number of facet is 252080, the number of segment is 39' and '[17:06:12] INFO: Done in 10.851s'.

The main 3D view shows a top-down perspective of a city block mesh. The mesh is rendered in a reddish-brown color. A blue wireframe outline highlights a specific region of the mesh, likely the ground plane. A 3D coordinate system with red, green, and blue axes is visible in the top right corner.

2. Methodology – Refine the predictions

The screenshot displays the UrbanMeshAnnotator interface. On the left, there are three main panels: 'Geometric Objects', 'Annotation', and 'Surface Mesh Selection'. The 'Geometric Objects' panel shows a table with one entry: 'Tile_+1987_+2...' with a blue square icon, 'TextureMode+flat+edges' mode, and a green checkmark in the 'View' column. The 'Annotation' panel includes a 'View' section with a 'Probability' dropdown set to 'below' and a slider at 100. Below this are 'Labels' for 'unclassified (U)', 'ground (G)', 'vegetation (V)', 'building (B)', 'water (W)', and 'vehicle (E)'. The 'Surface Mesh Selection' panel has 'Selection mode' set to 'Segments', 'Smart mode' set to 'none', and 'Basic selection' options including 'Multi-selection rings' (0), 'Expand/Reduce' (0), and 'Lasso'. At the bottom, the 'Console' panel shows two log messages: '[16:31:22] INFO: There is not split segment been selected!' and '[16:31:22] INFO: Done in 14.395s'. The main 3D view on the right shows a city block with buildings colored in yellow and green, ground in brown, and vegetation in green. A mouse cursor is visible over the ground area. A 3D coordinate system with red, green, and blue axes is in the top right corner.

4. Results – Initial segmentation results



(a) Original

(b) Segments

(c) Predictions

(d) Truth

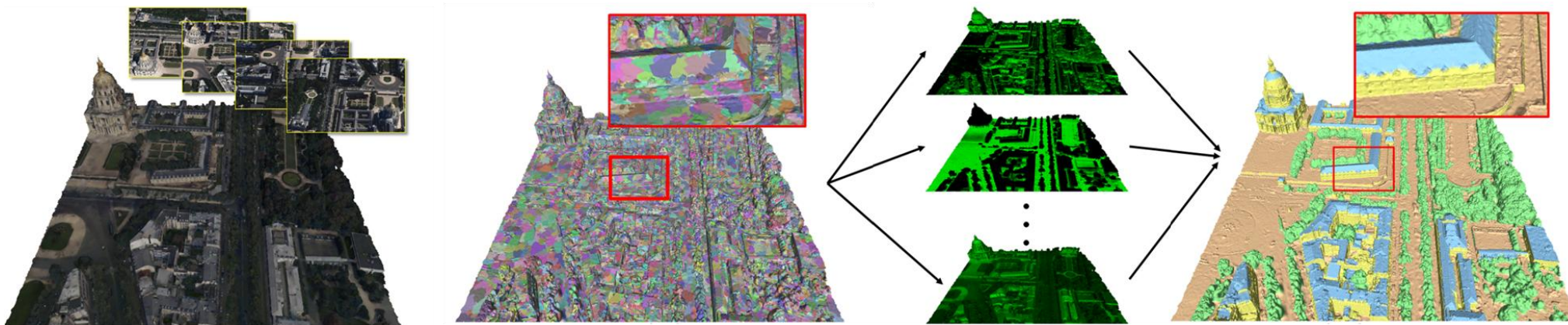
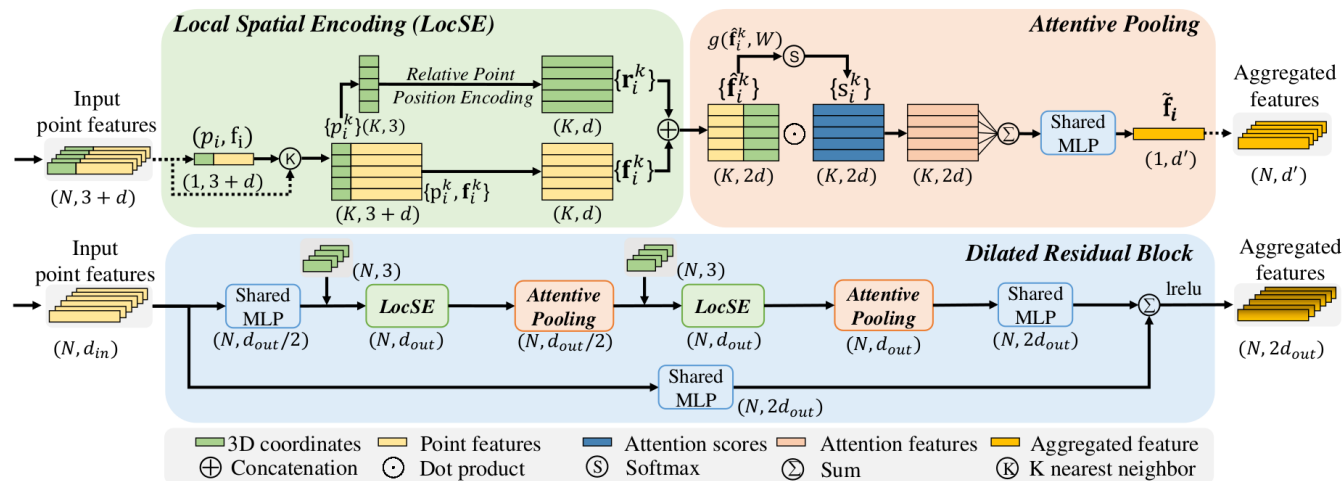
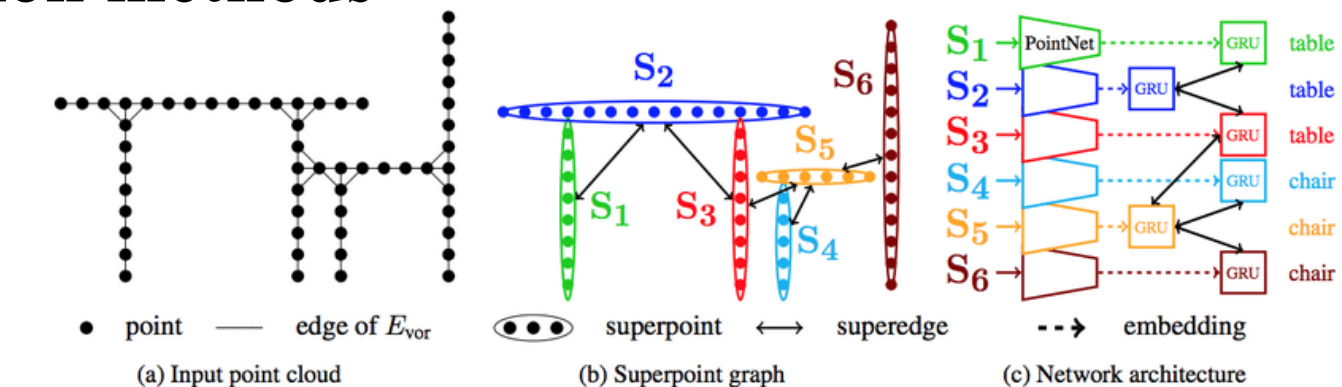
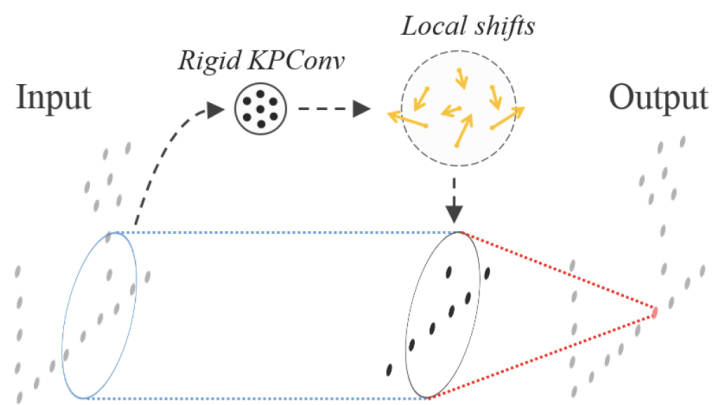
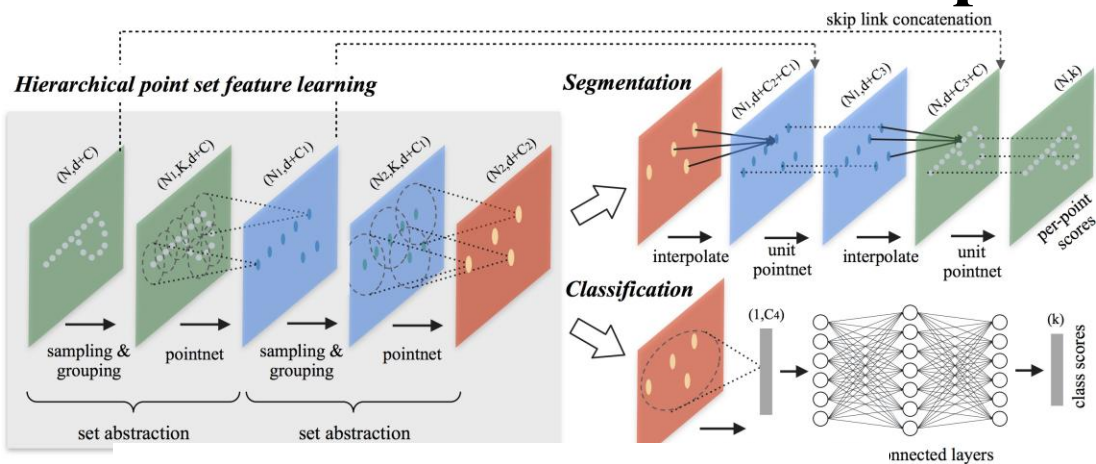
(e) Error maps

Terrain Building Water High vegetation Vehicle Boat

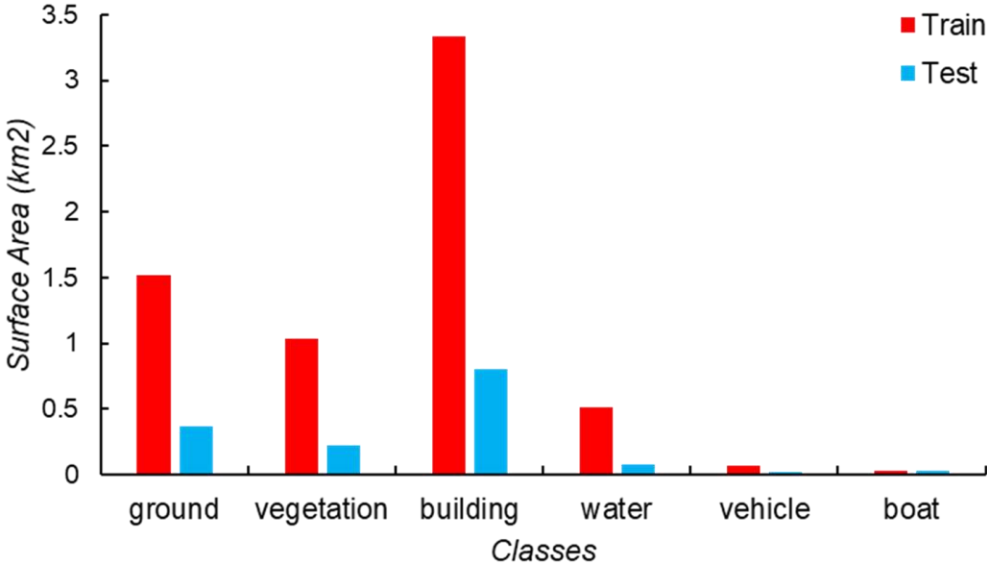
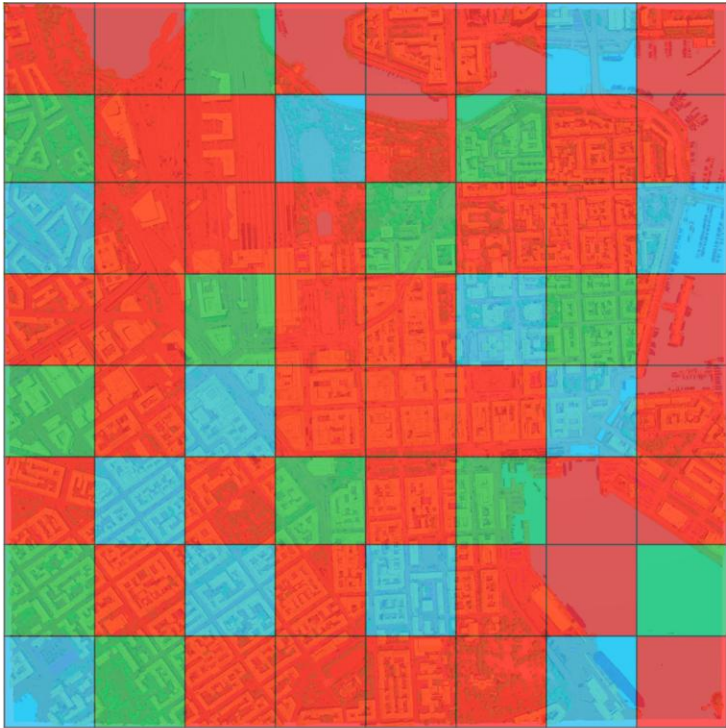
4. Results – Final results



4. Results – Evaluation of competition methods



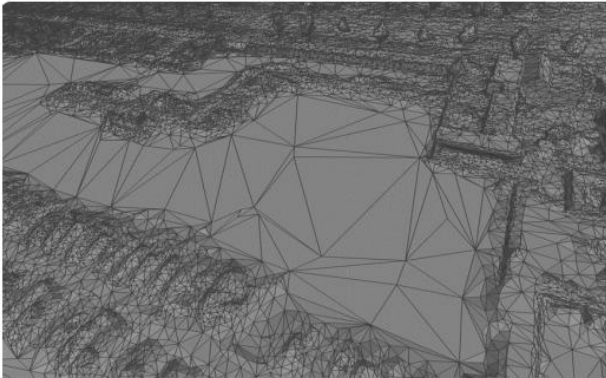
4. Results – Data splits and sampling



■ Train ■ Validate ■ Test



(a) Texture Mesh



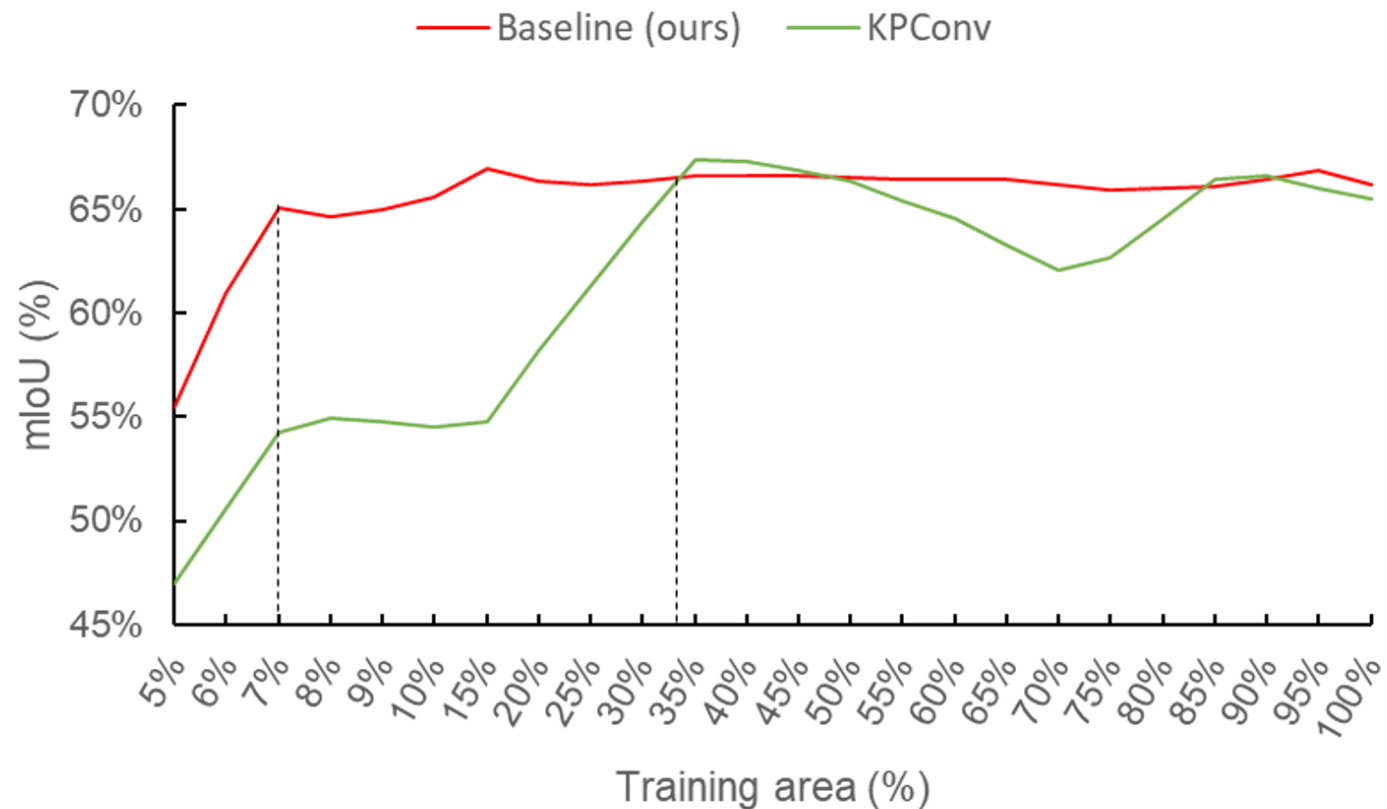
(b) Wireframe



(c) Sampled Point Cloud

4. Results – Comparison

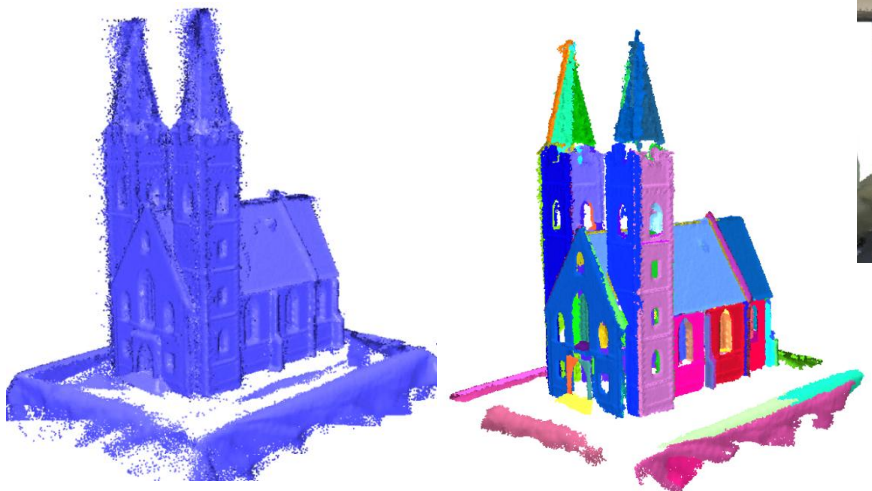
	Terrain	High vegetation	Building	Water	Vehicle	Boat	mIoU	OA	mAcc	mF1	t_{train}
PointNet (Qi et al., 2017a)	56.3	14.9	66.7	83.8	0.0	0.0	36.9 \pm 2.3	71.4 \pm 2.1	46.1 \pm 2.6	44.6 \pm 3.2	1.8
RandLaNet (Hu et al., 2020)	38.9	59.6	81.5	27.7	22.0	2.1	38.6 \pm 4.6	74.9 \pm 3.2	53.3 \pm 5.1	49.9 \pm 4.8	10.8
SPG (Landrieu and Simonovsky, 2018)	56.4	61.8	87.4	36.5	34.4	6.2	47.1 \pm 2.4	79.0 \pm 2.8	64.8 \pm 1.2	59.6 \pm 1.9	17.8
PointNet++ (Qi et al., 2017b)	68.0	73.1	84.2	69.9	0.5	1.6	49.5 \pm 2.1	85.5 \pm 0.9	57.8 \pm 1.8	57.1 \pm 1.7	2.8
RF-MRF (Rouhani et al., 2017)	77.4	87.5	91.3	83.7	23.8	1.7	60.9 \pm 0.0	91.2 \pm 0.0	65.9 \pm 0.0	68.1 \pm 0.0	1.1
KPConv (Thomas et al., 2019)	86.5	88.4	92.7	77.7	54.3	13.3	68.8 \pm5.7	93.3 \pm1.5	73.7 \pm5.4	76.7 \pm5.8	23.5
Baseline	83.3	90.5	92.5	86.0	37.3	7.4	66.2 \pm 0.0	93.0 \pm 0.0	70.6 \pm 0.0	73.8 \pm 0.0	1.2



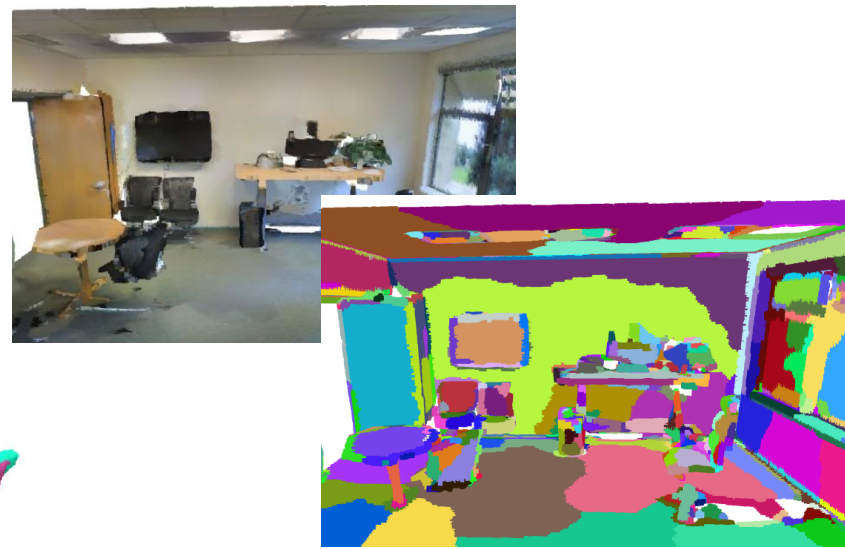


3. Planarity-sensible semantic mesh segmentation

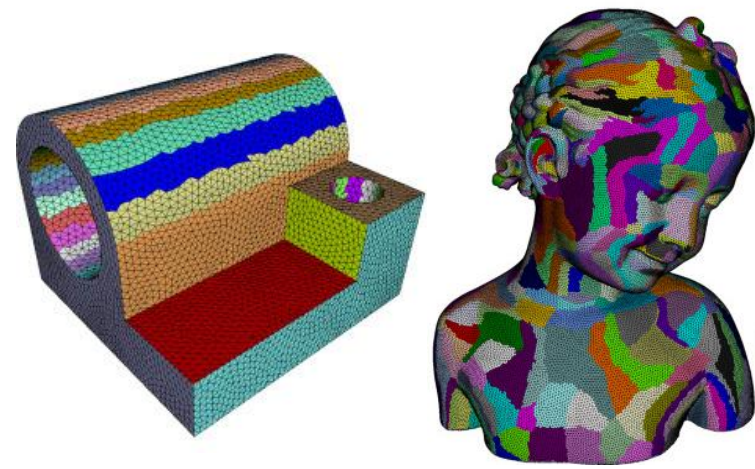
Existing approaches



[Schnabel et al. 2007]

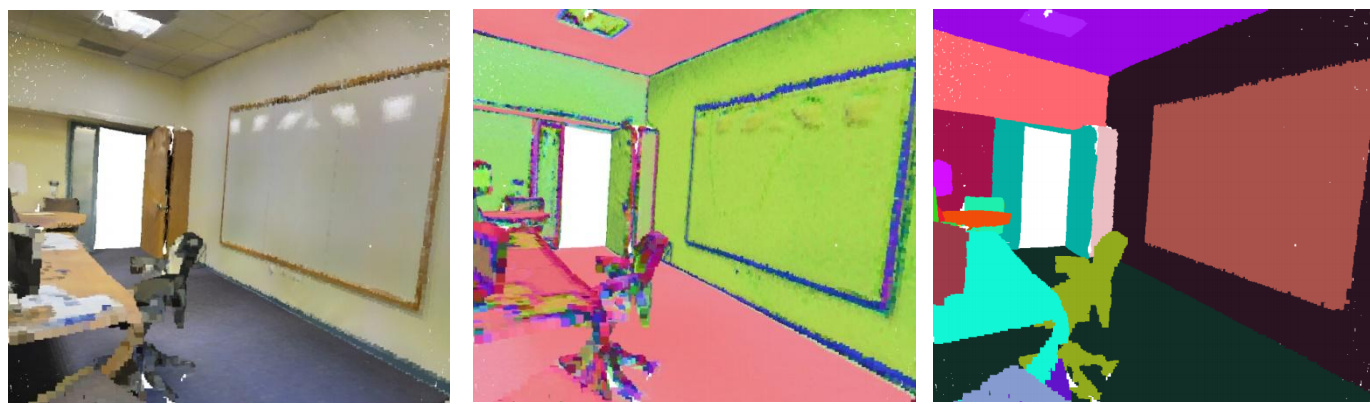


[Landrieu and Martin 2018]



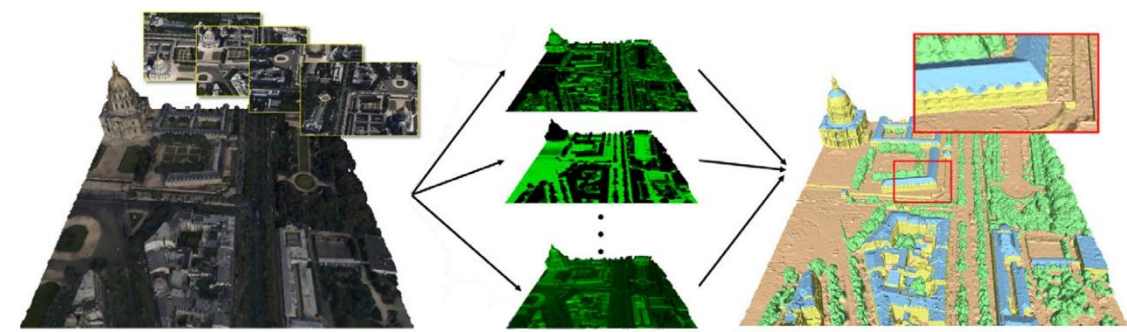
[Cohen-Steiner et al. 2006]

Over-segmentation of 3D Data



[Landrieu and Boussaha 2019]

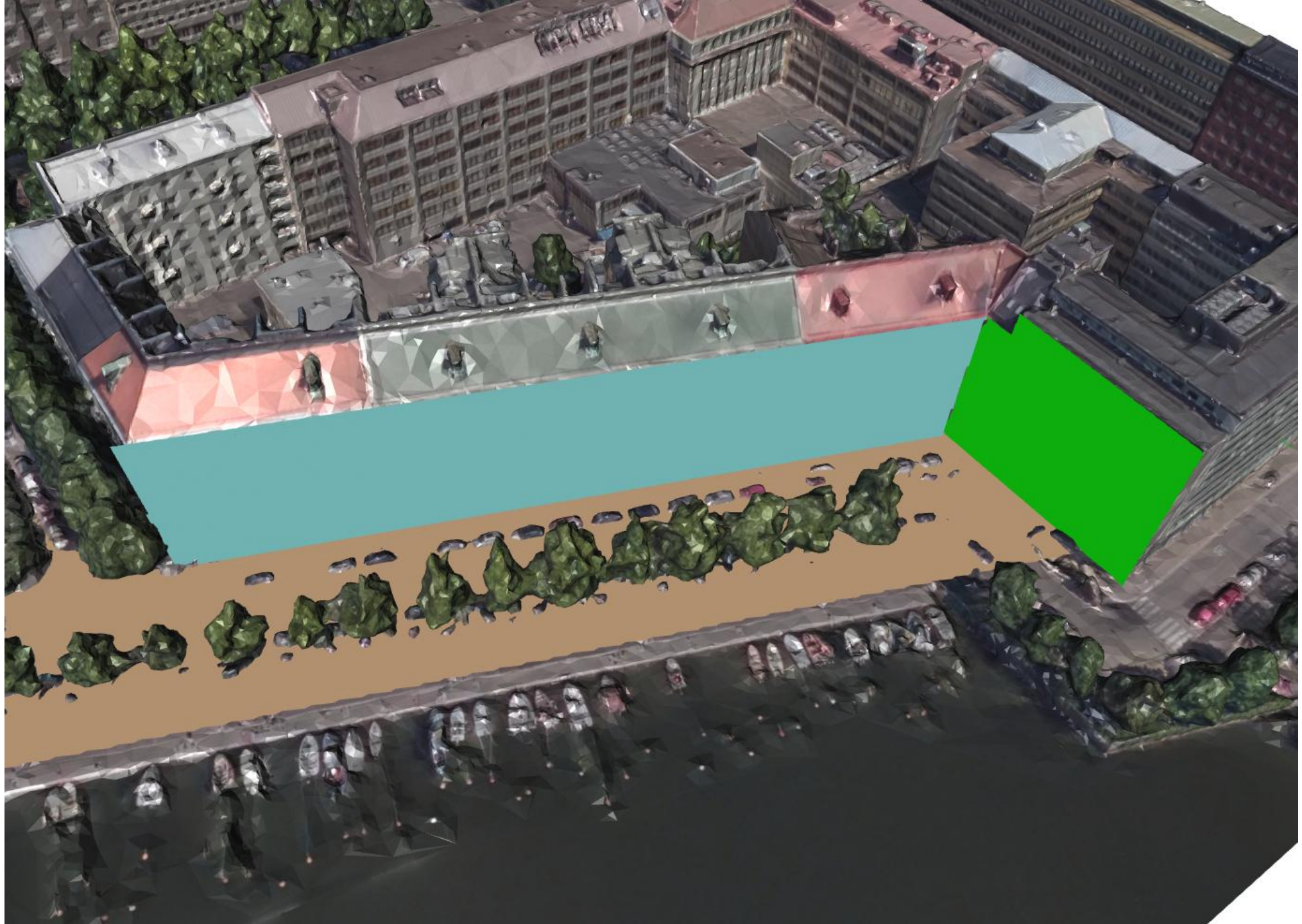
Semantic segmentation of 3D Data



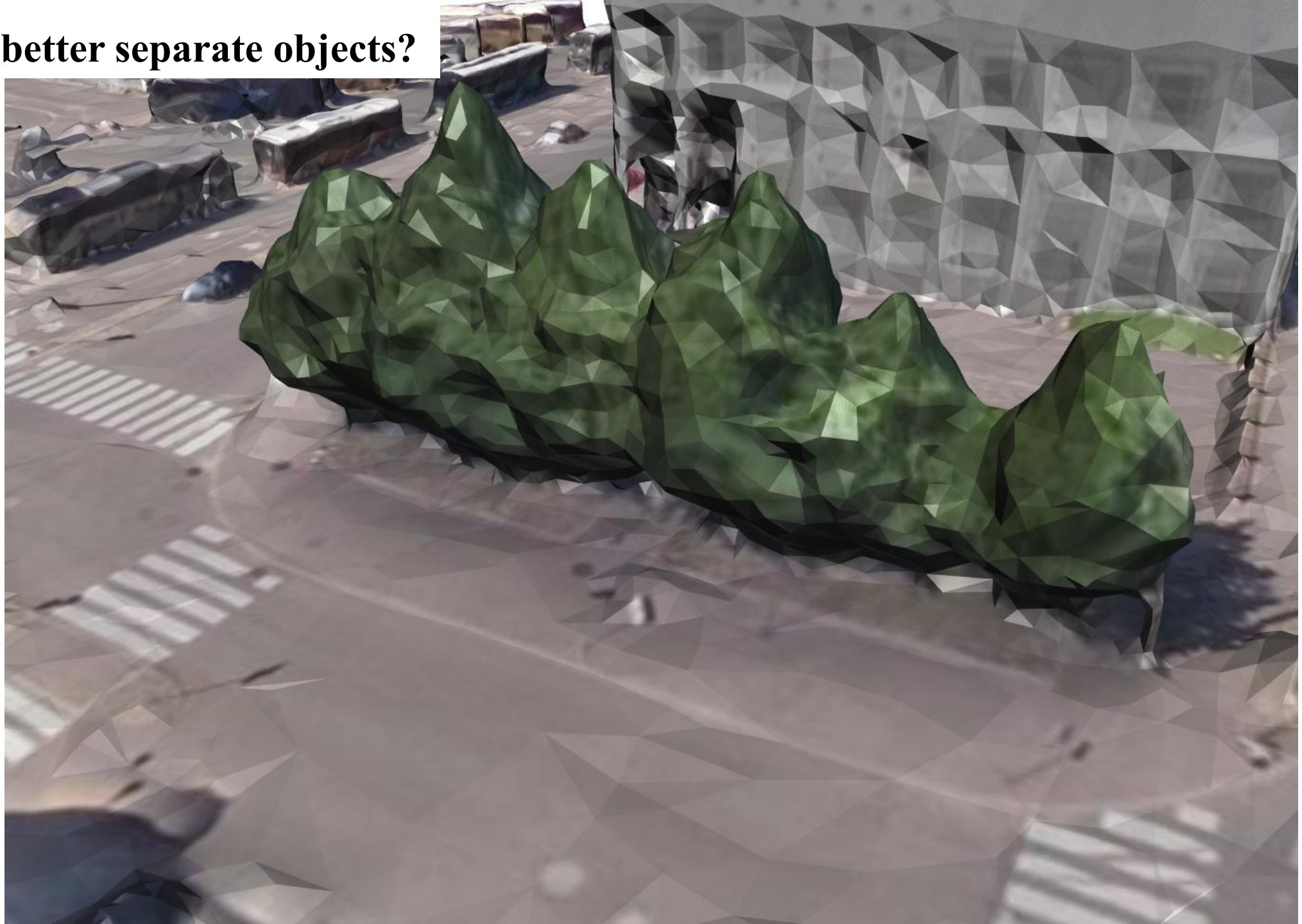
[Rouhani et al. 2017]

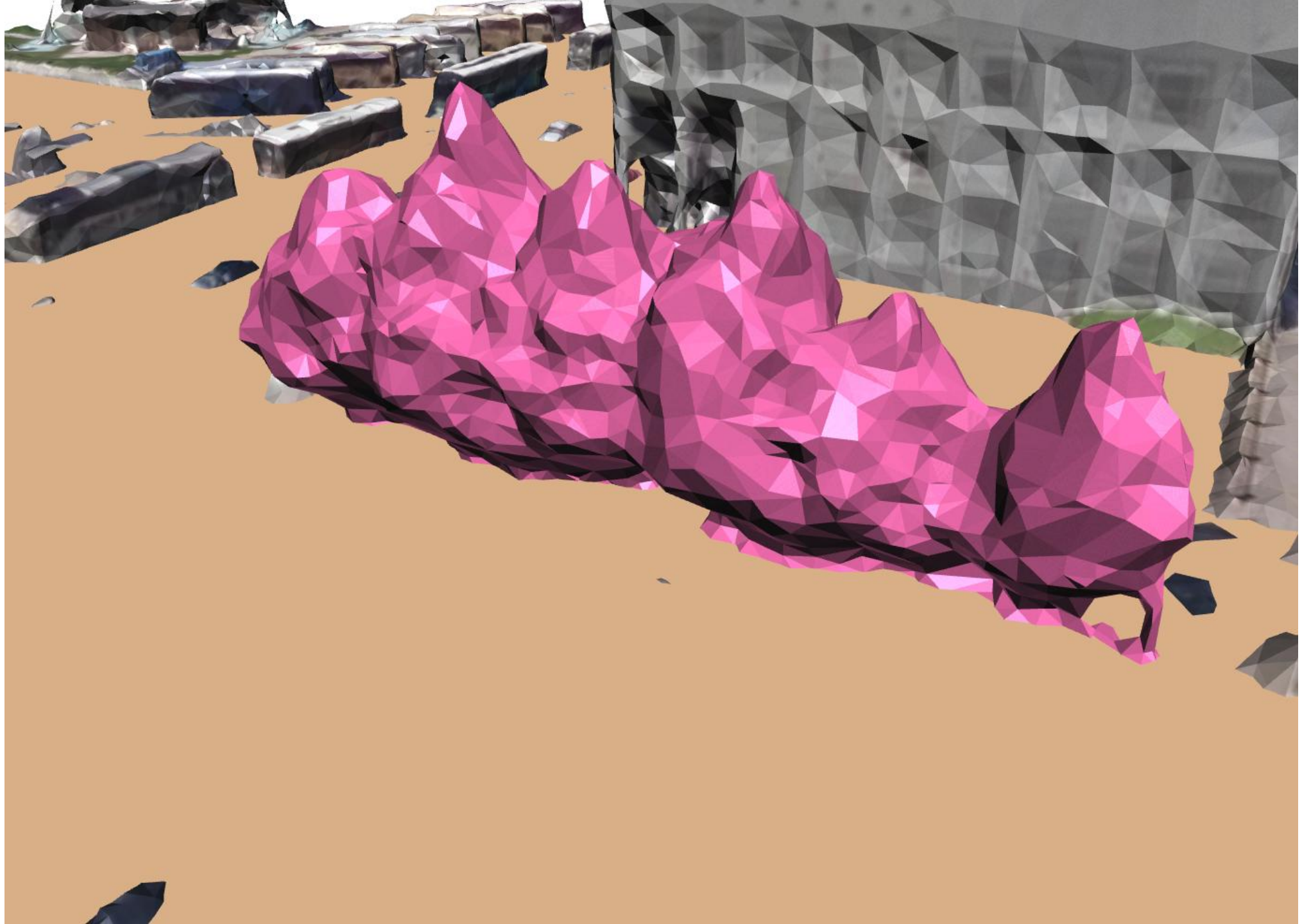
How to better separate objects?

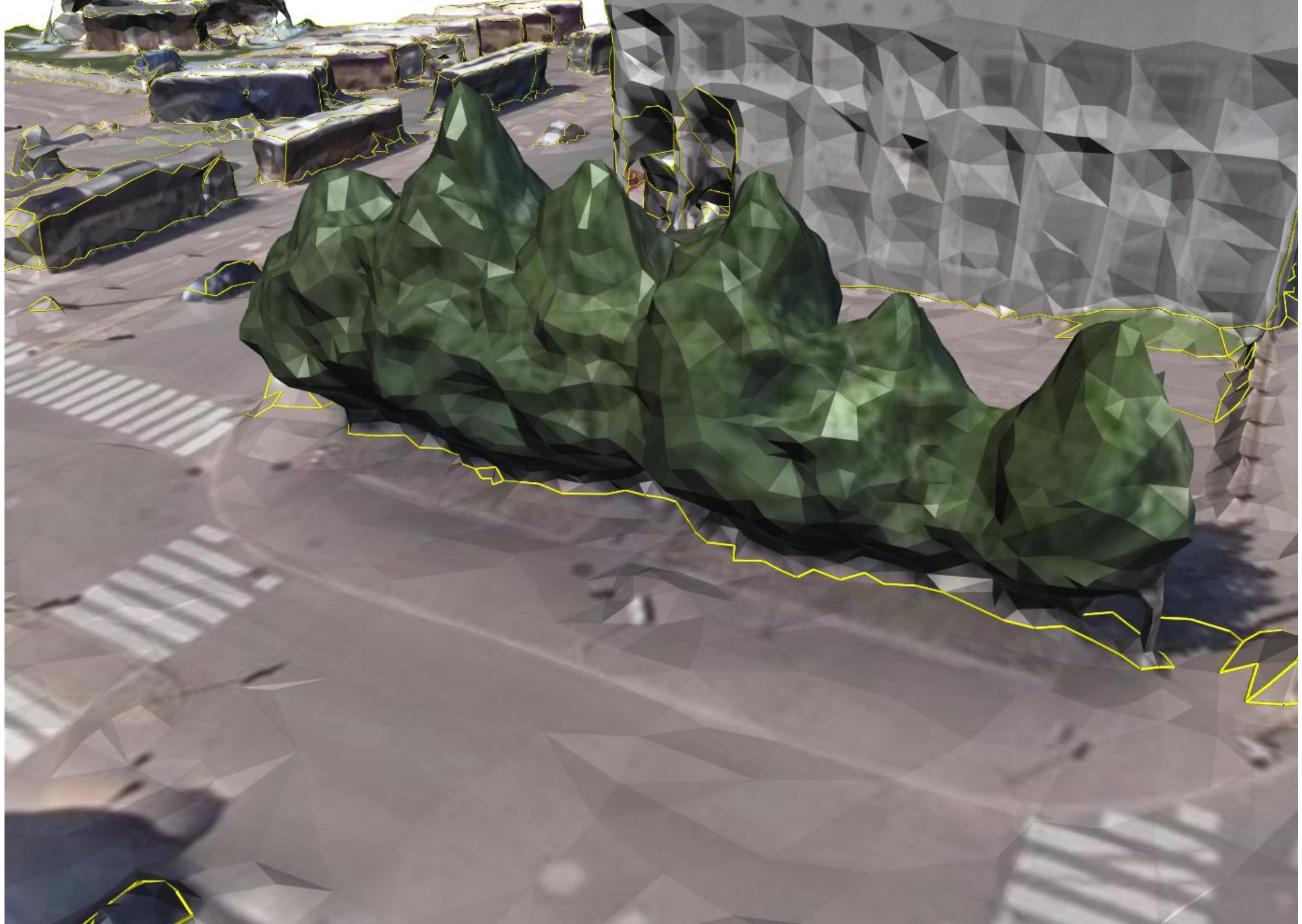




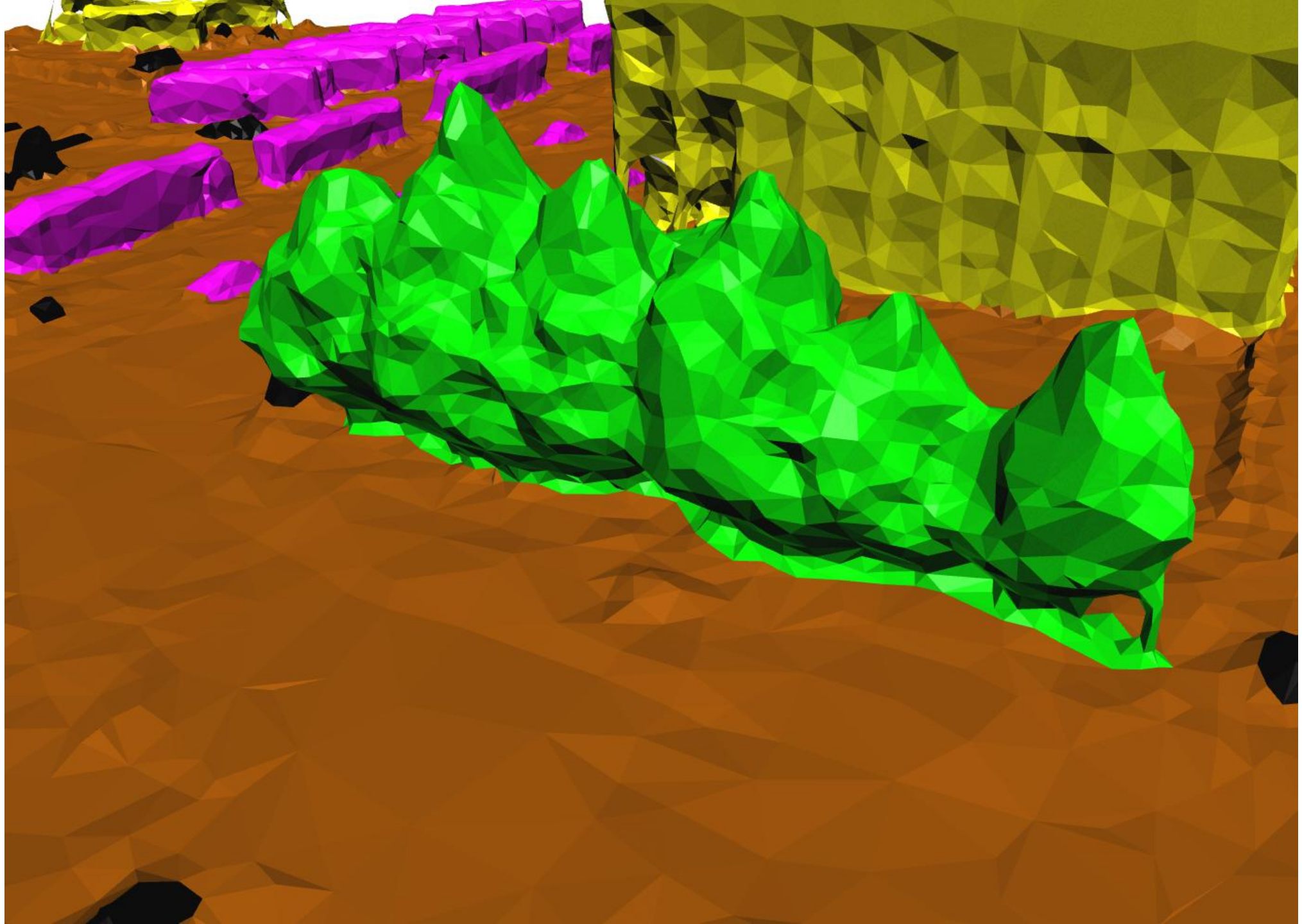
How to better separate objects?



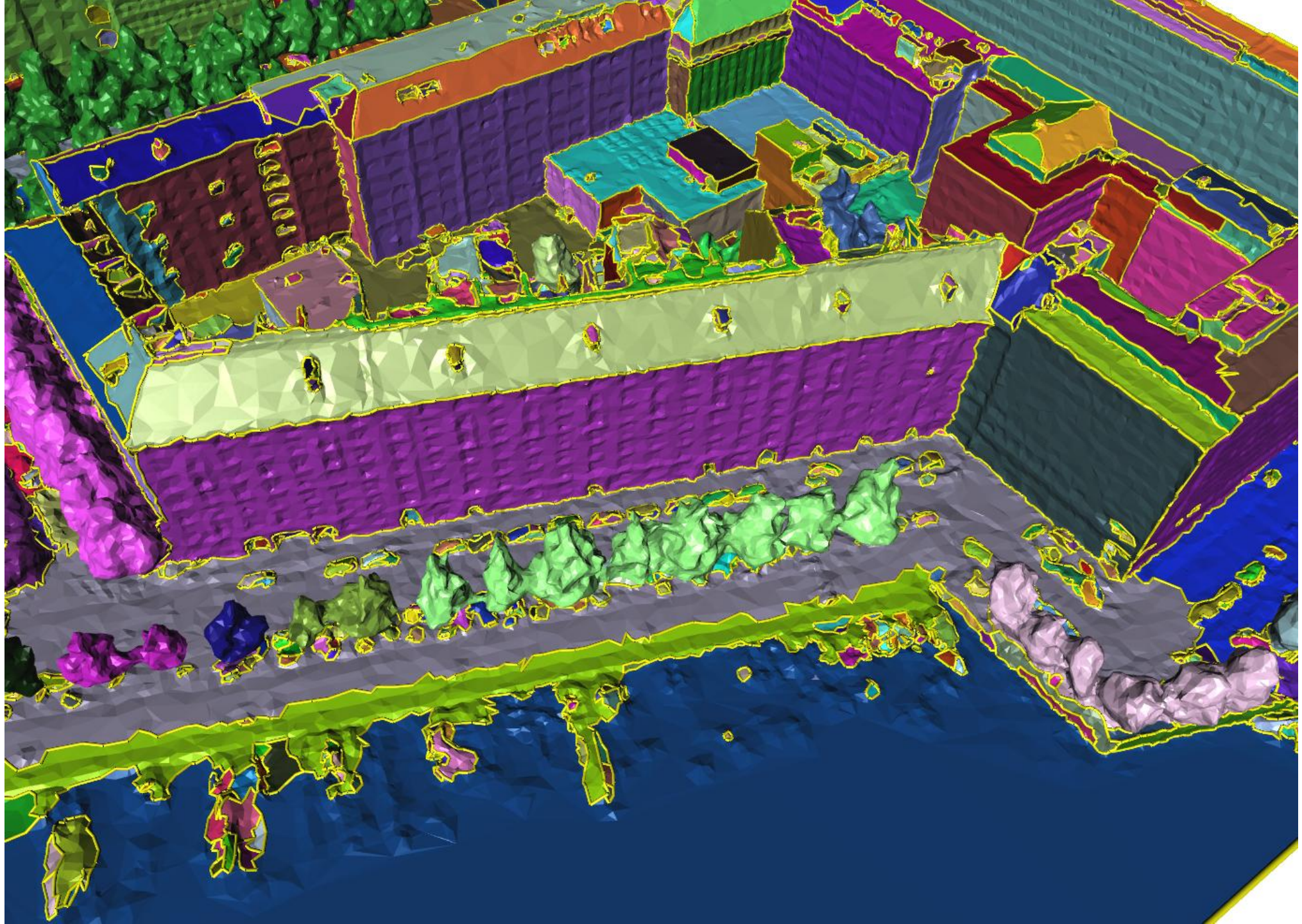


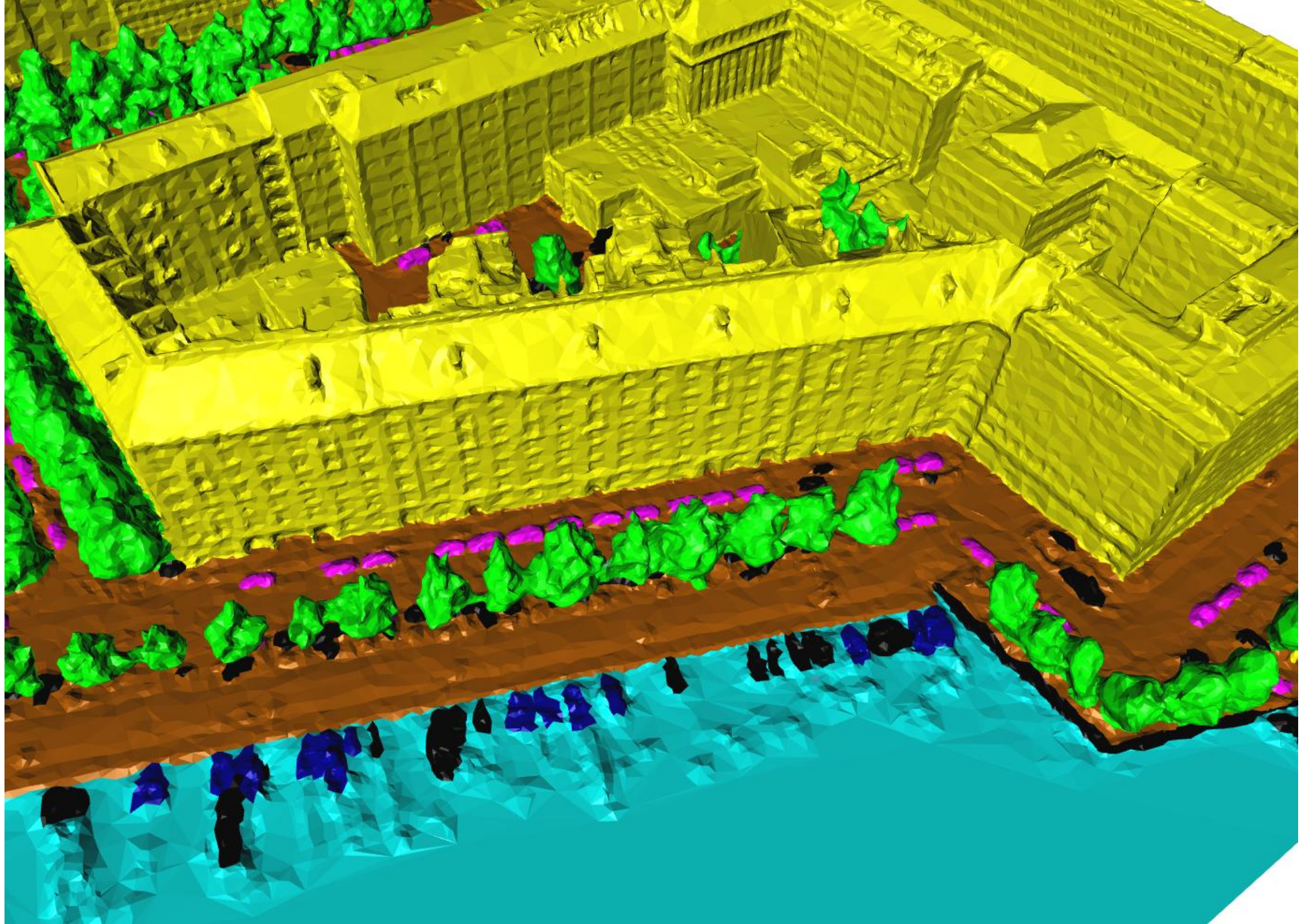








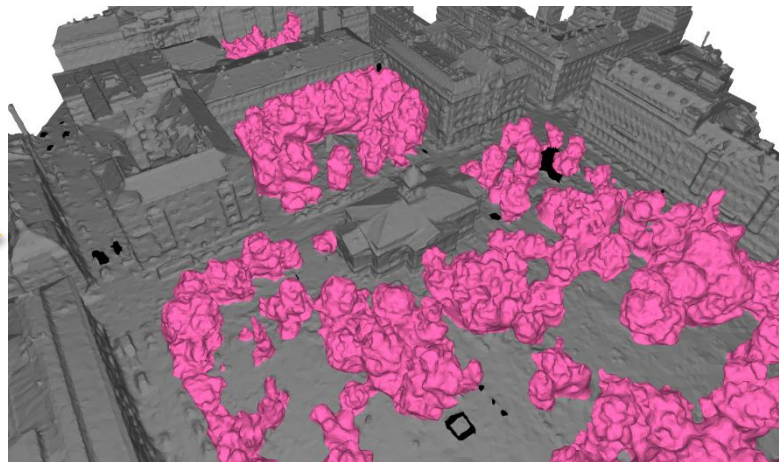




Planarity-sensible over-segmentation



Input mesh



Planar and non-planar classification



Over-segmentation

Incremental segmentation



Seed Face



Added Face



Non-added Face



Neighboring Face



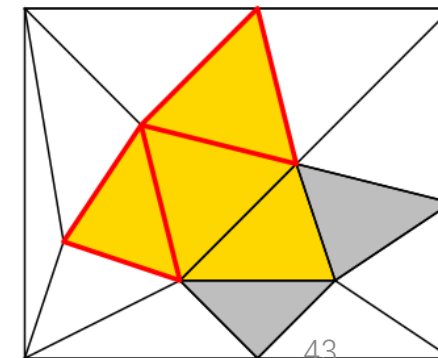
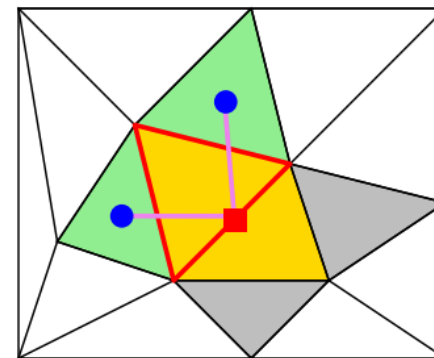
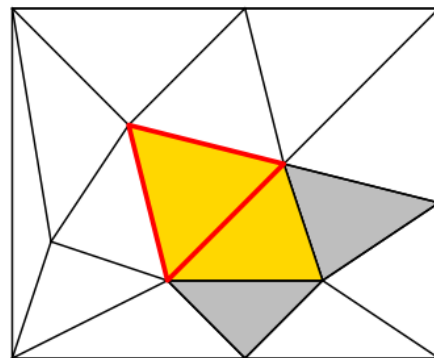
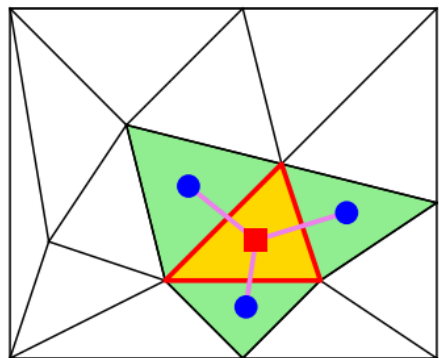
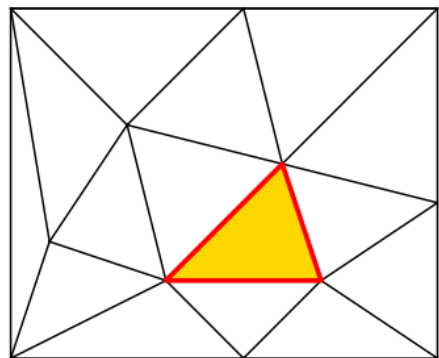
Region Node



Face Node



Graph Edge



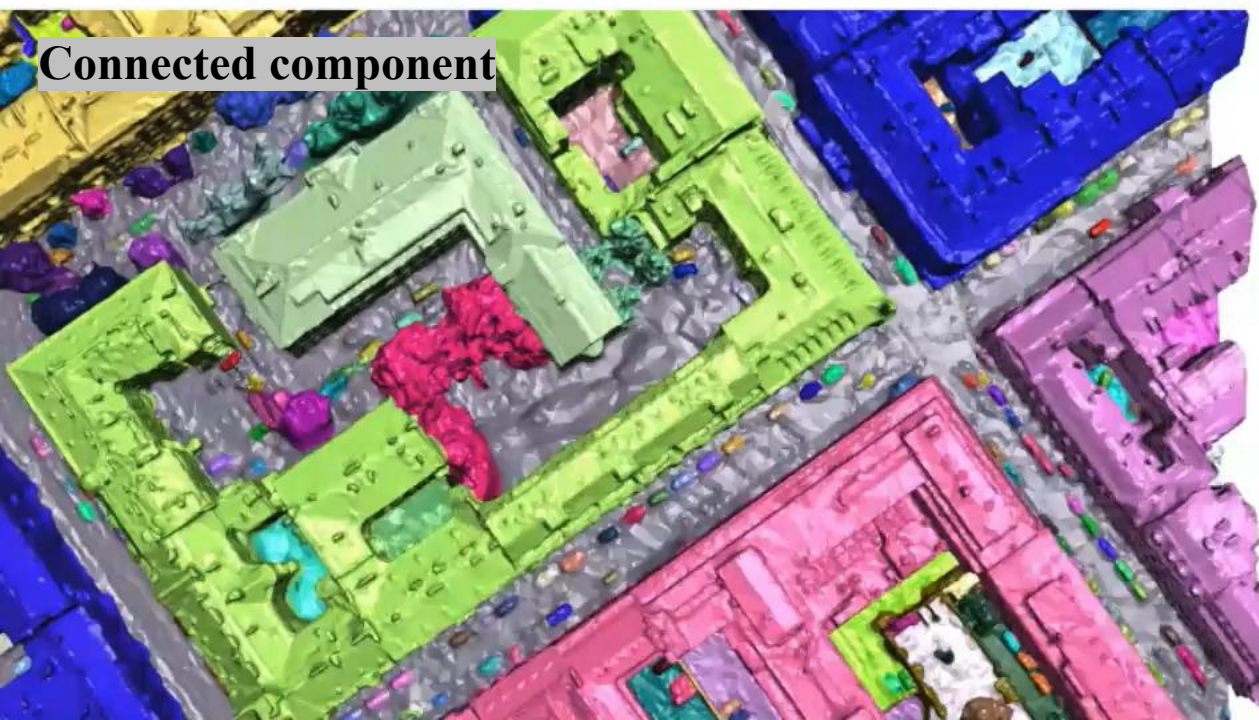
Texture mesh



Wireframe



Connected component



Ours





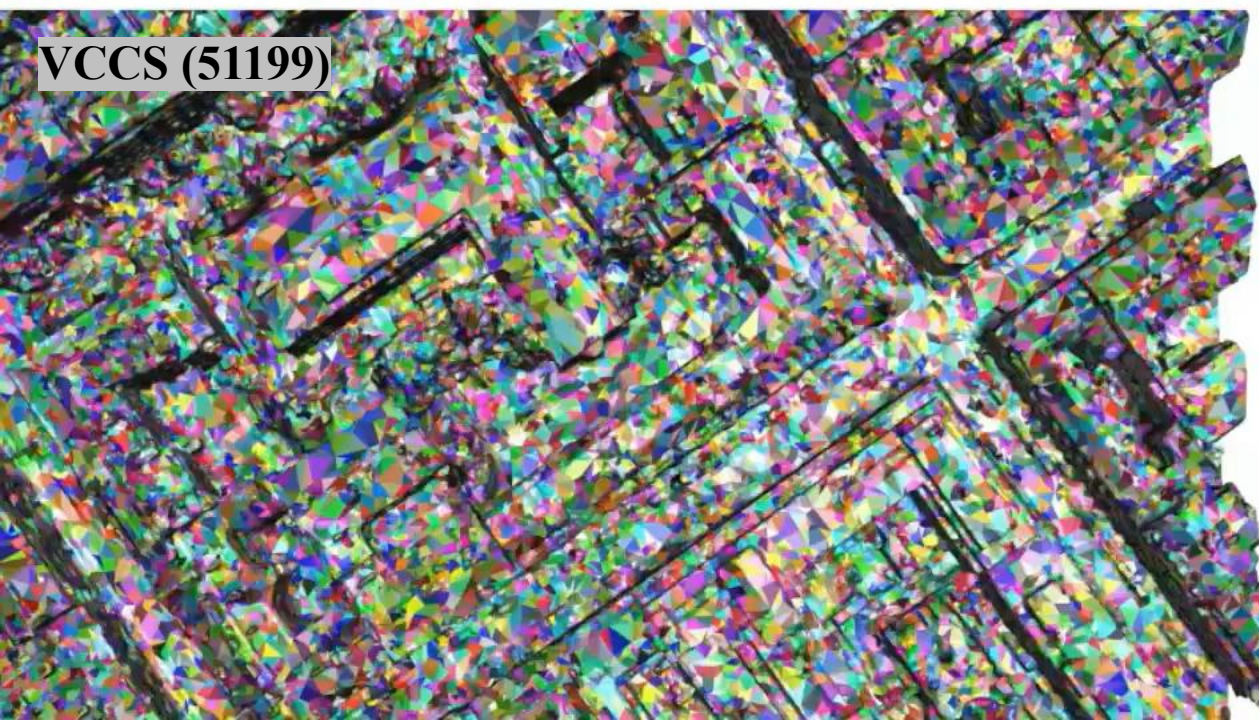
SP (92010)



SC (85126)



VCCS (51199)



Ours (8637)



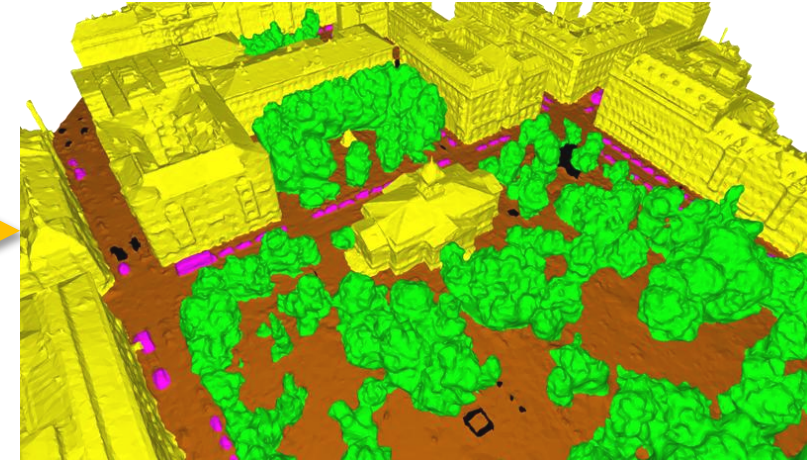
Semantic classification



Input mesh

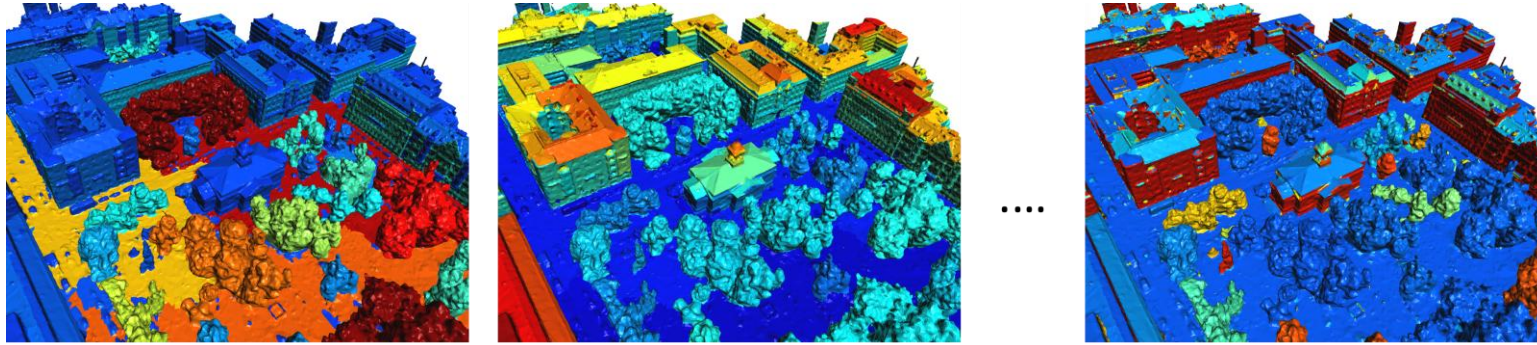


Over-segmentation

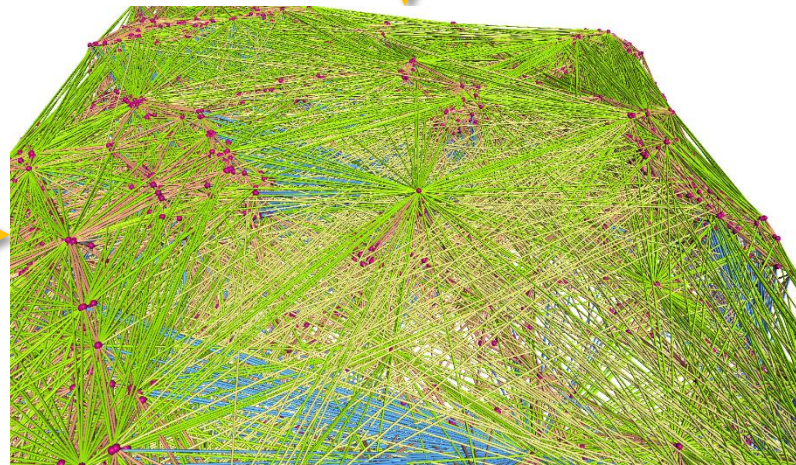


Semantic segmentation

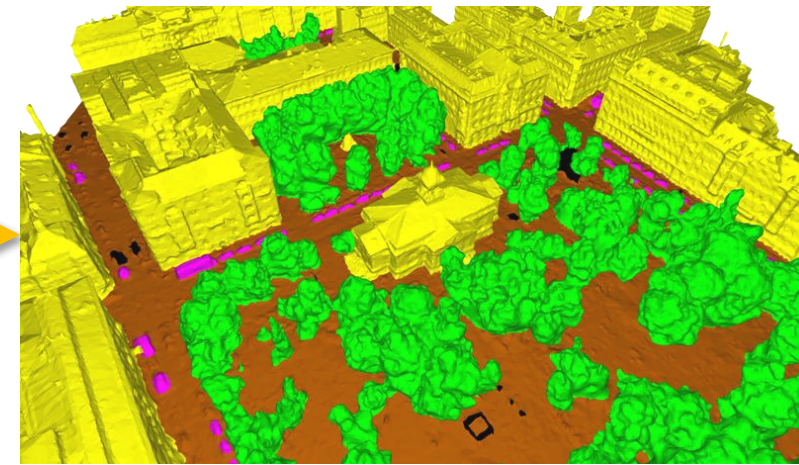
Feature extraction



Input mesh



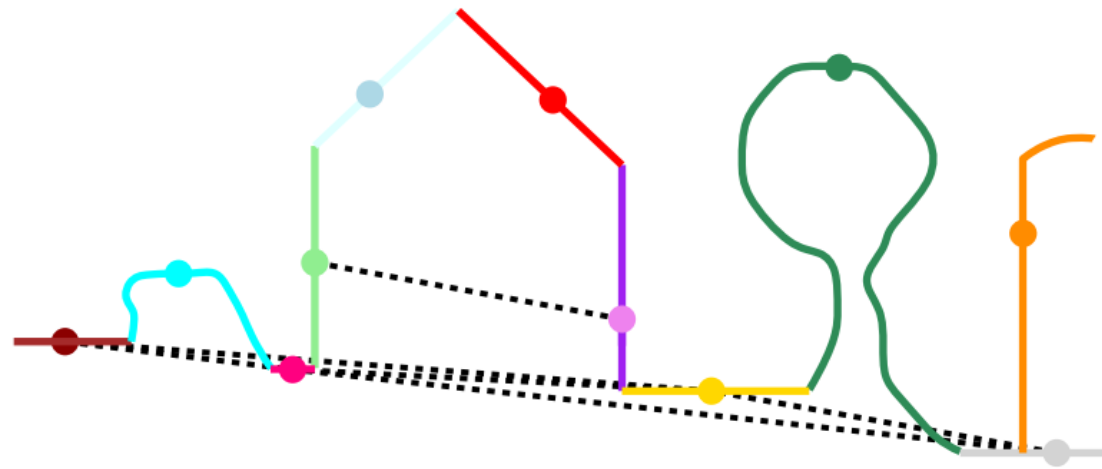
Graphs



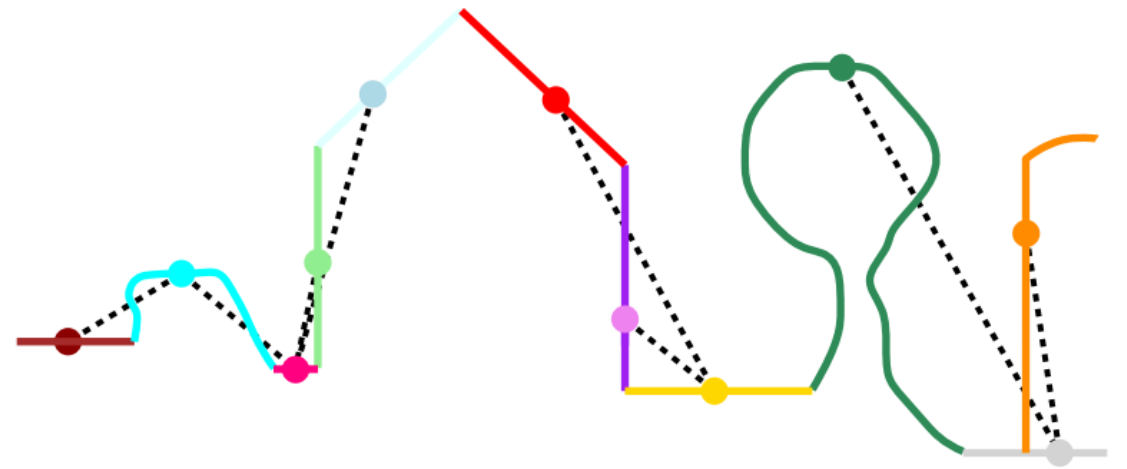
Semantic segmentation

Classification via GCN

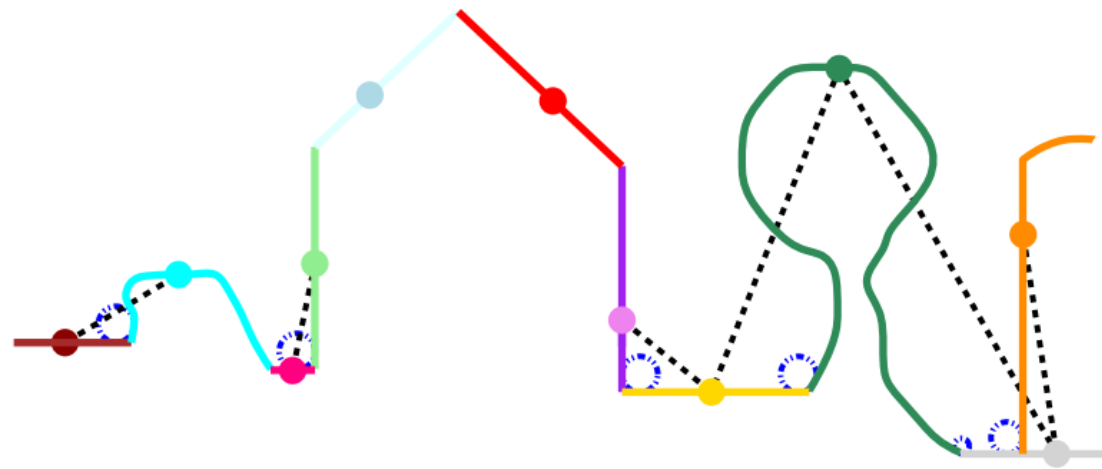
Edge connections



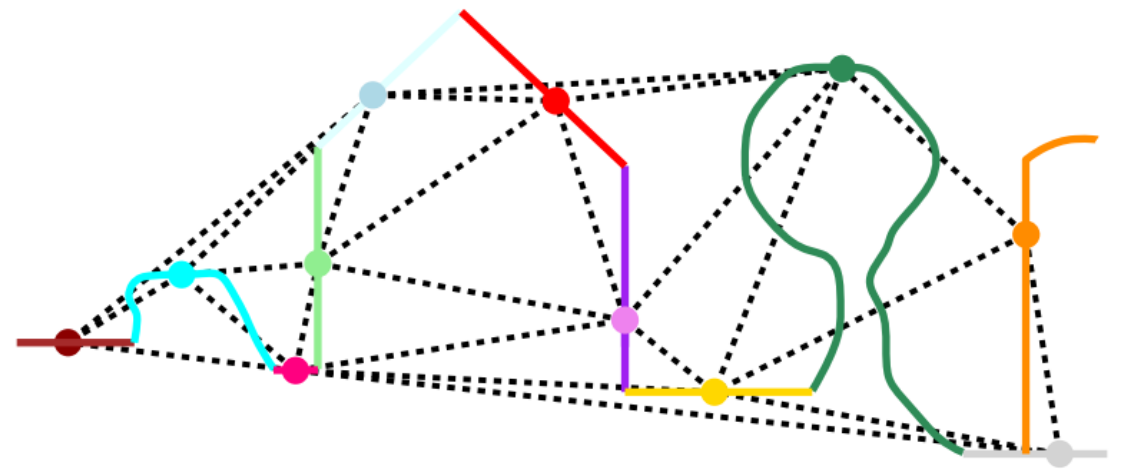
Parallelism edges



Connecting-ground edges



ExMAT edges

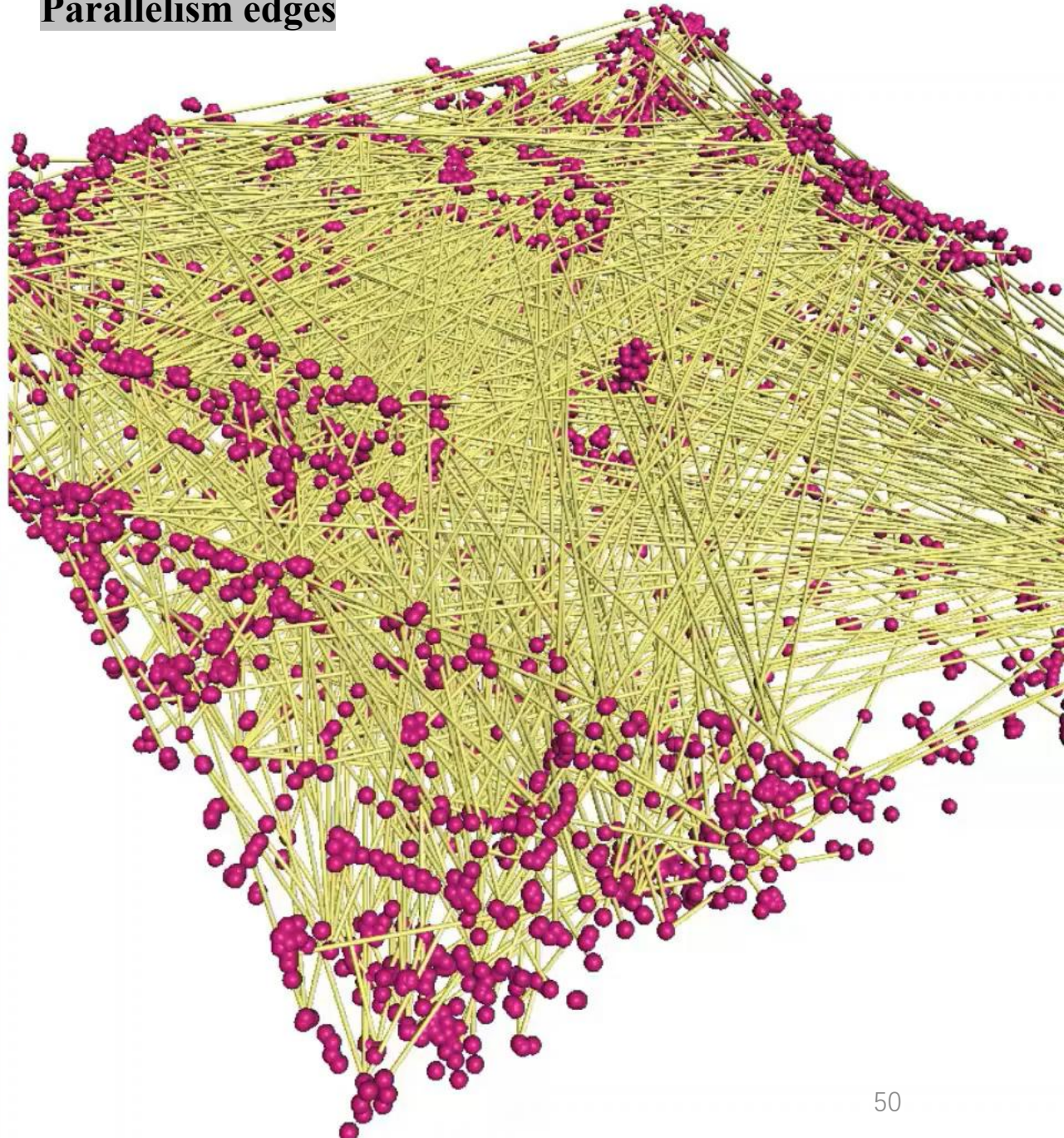


Spatially-proximate edges

Segments



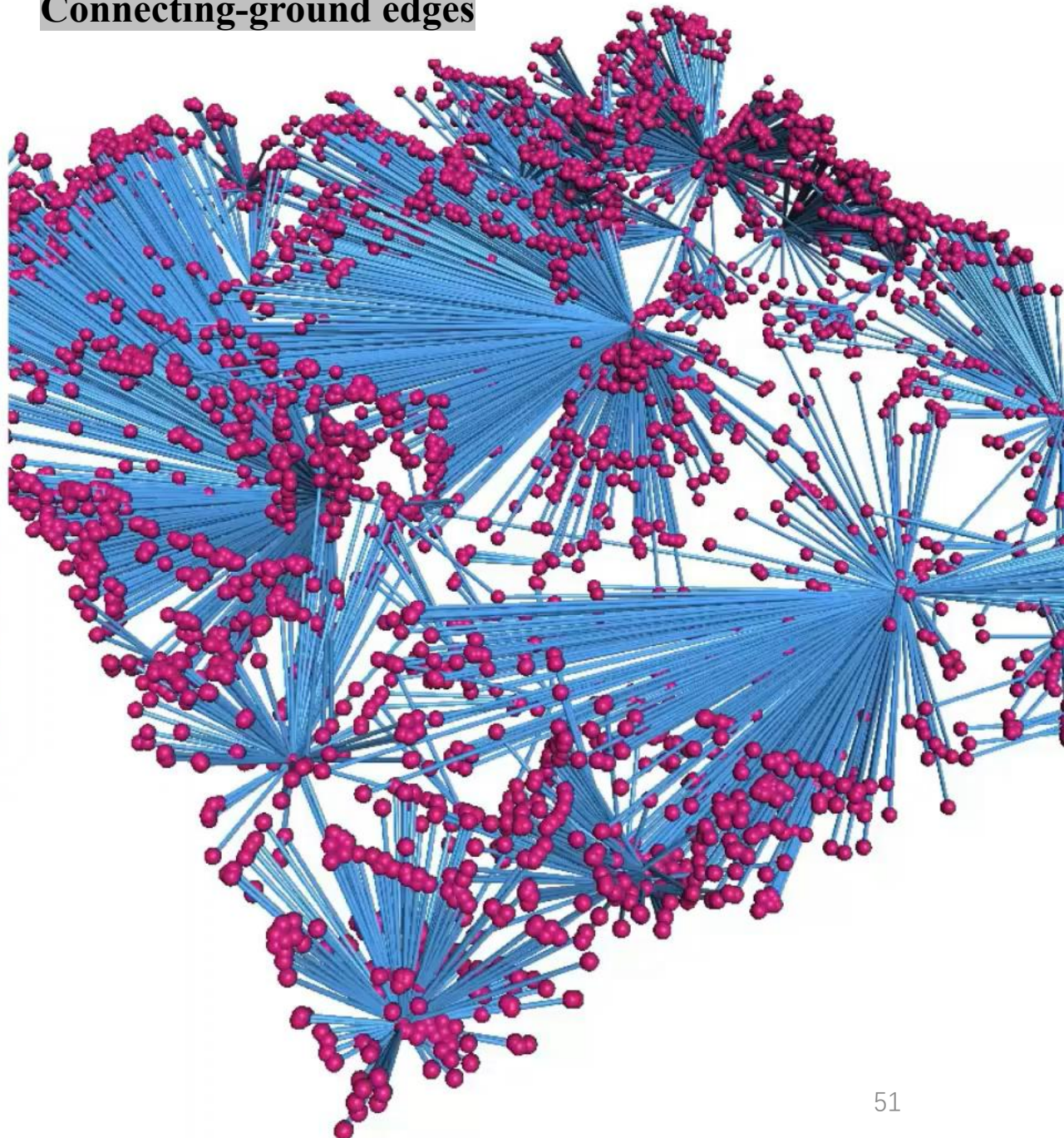
Parallelism edges



Segments



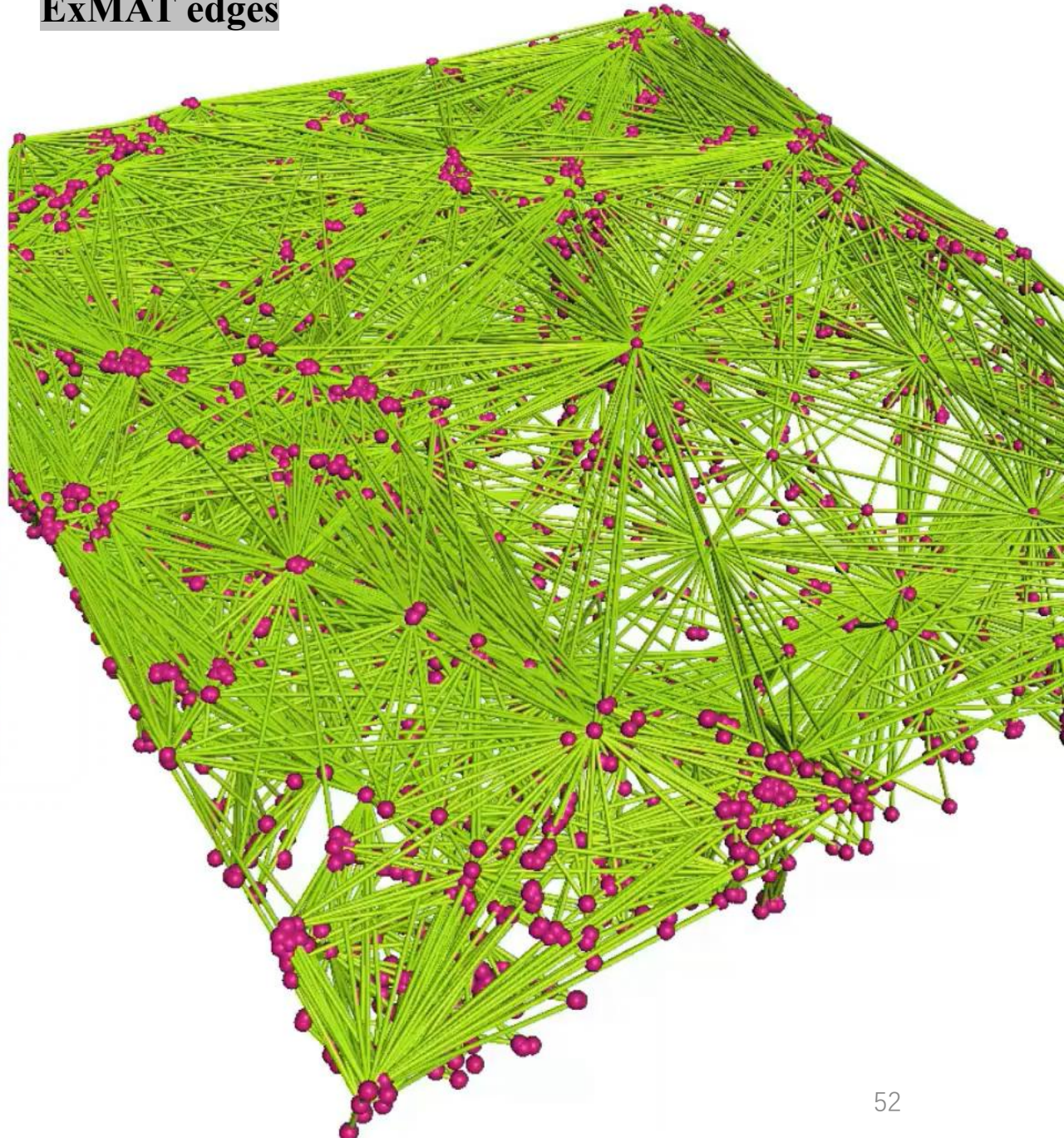
Connecting-ground edges



Segments



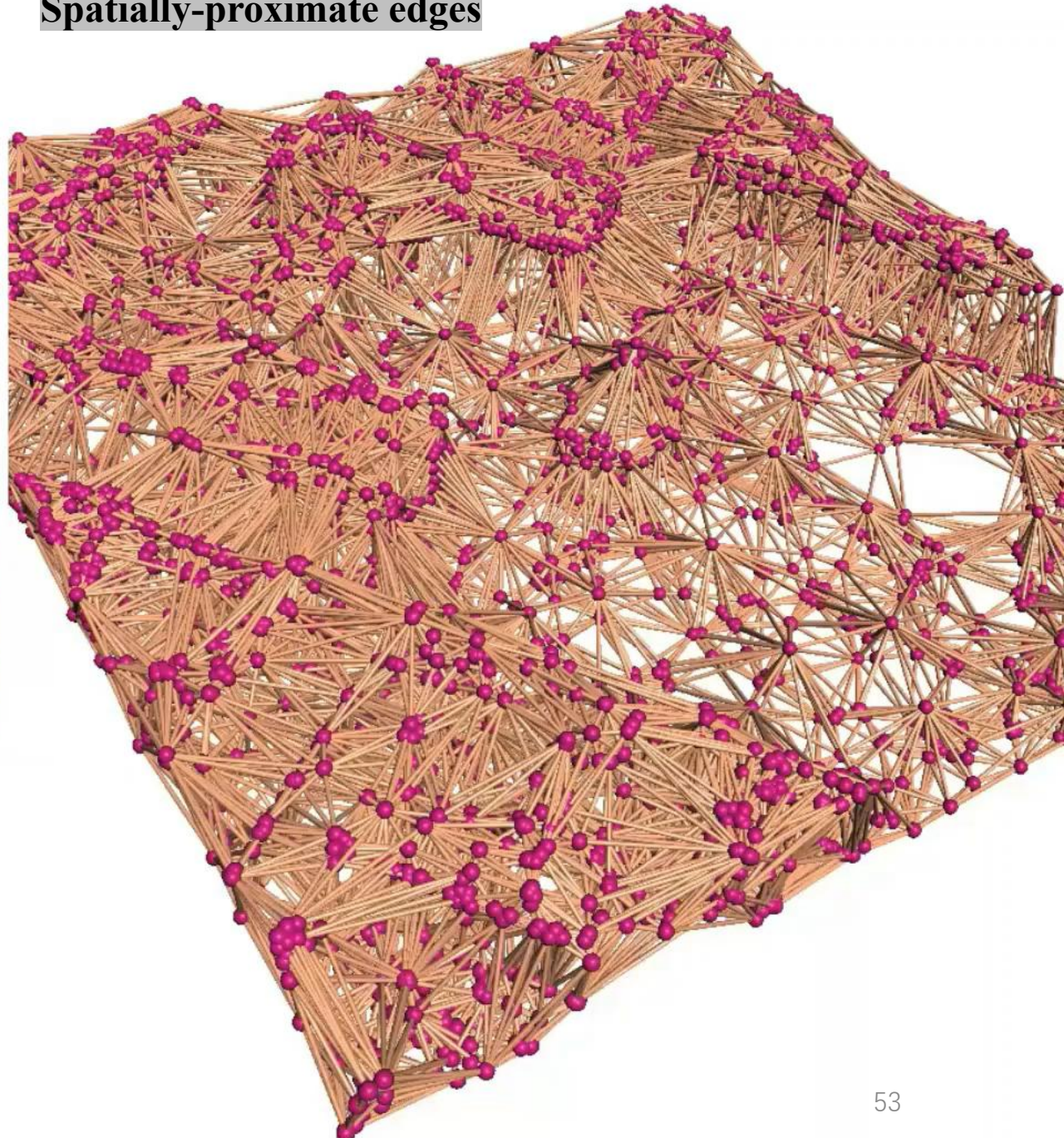
ExMAT edges



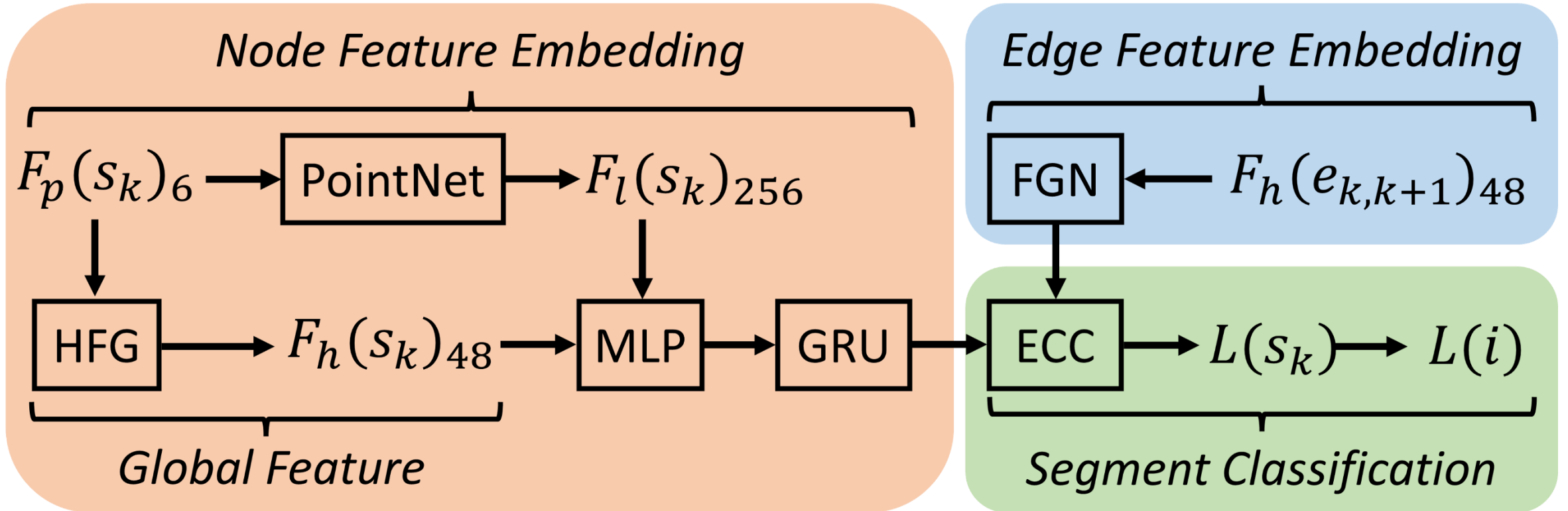
Segments



Spatially-proximate edges



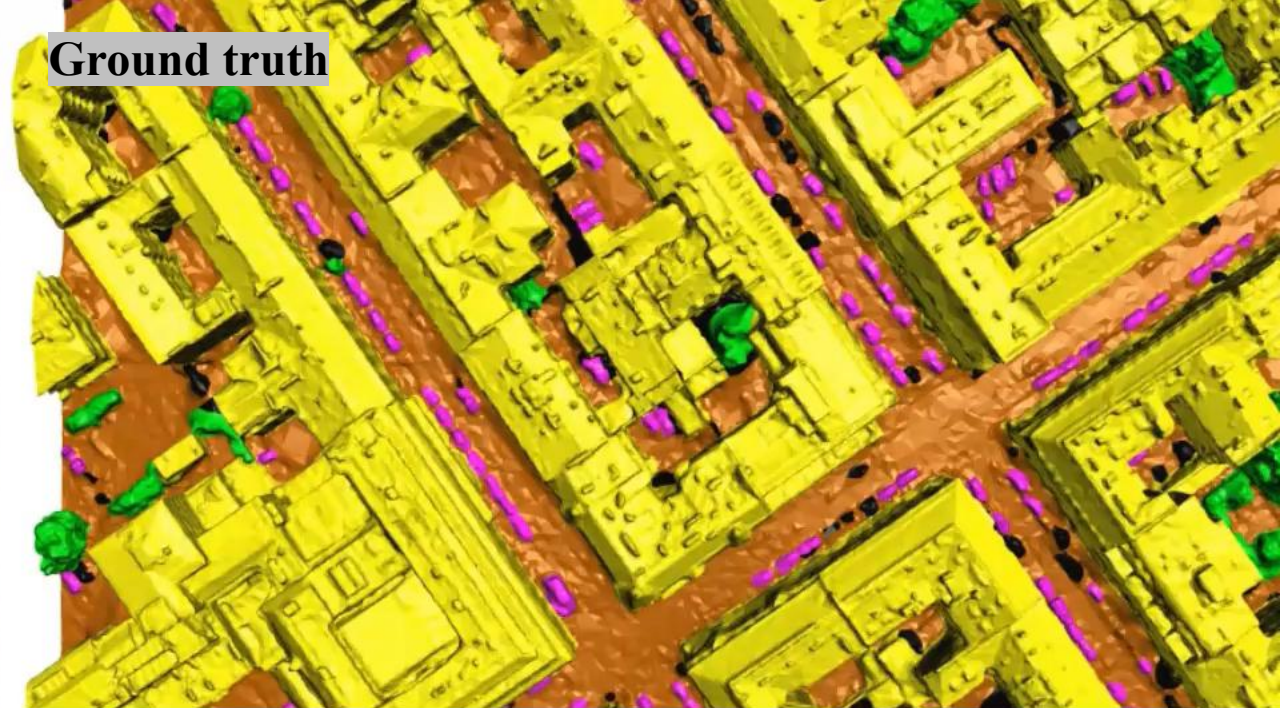
Feature embedding



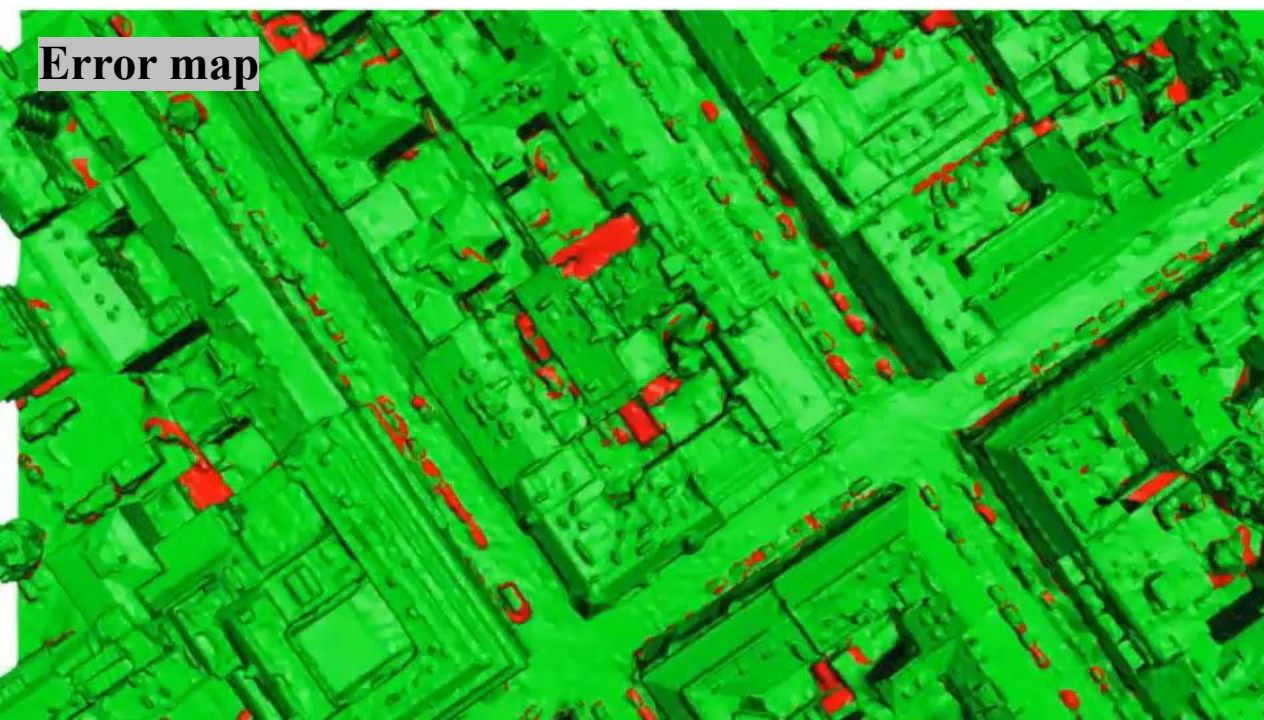
Texture mesh



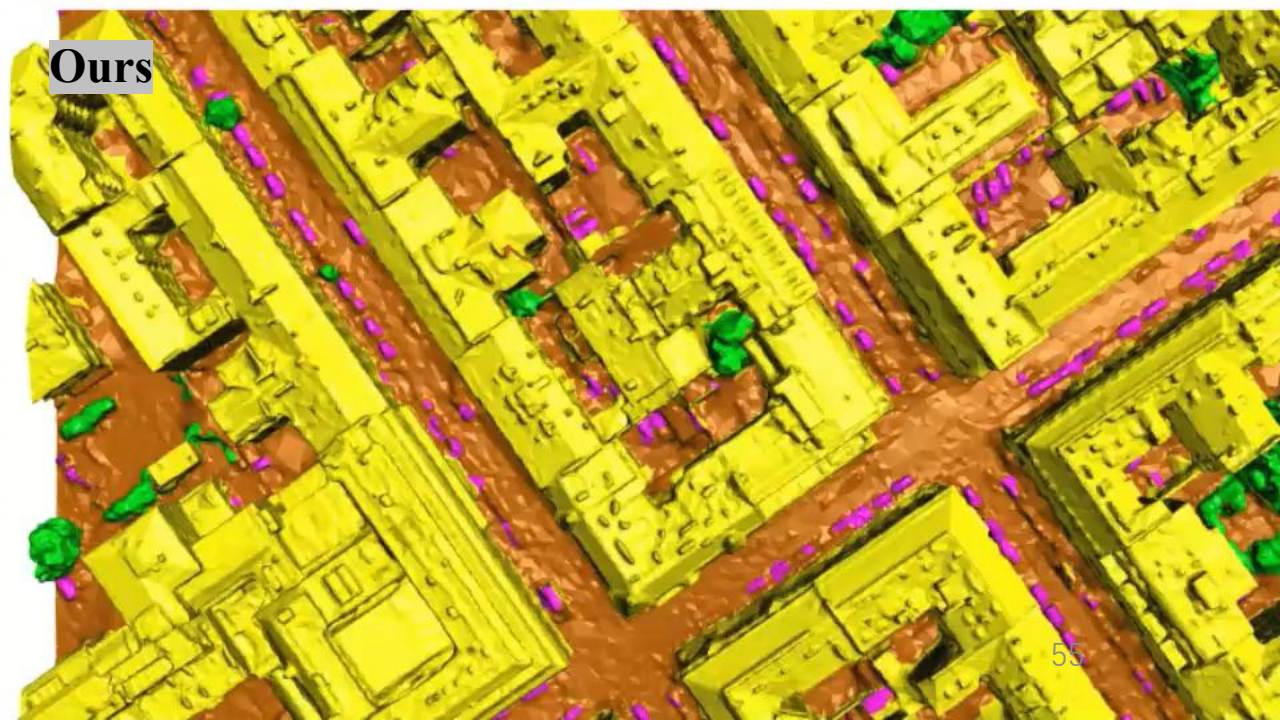
Ground truth



Error map



Ours



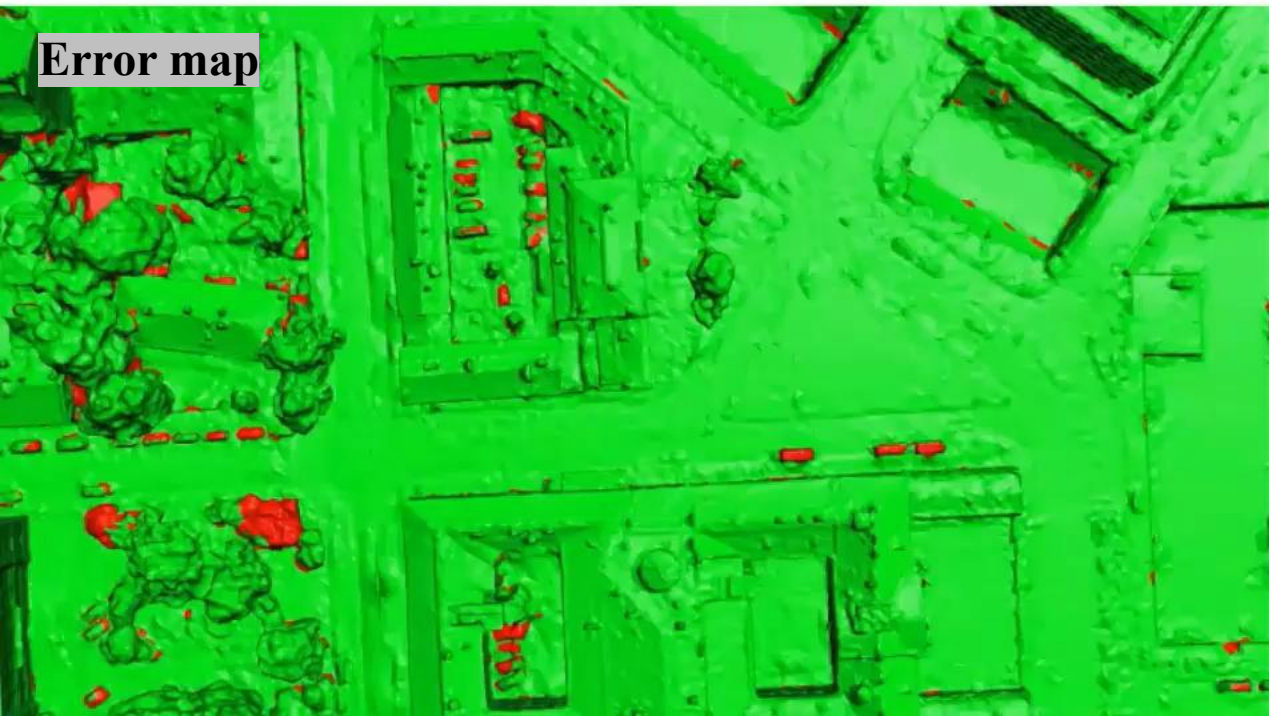
Texture mesh



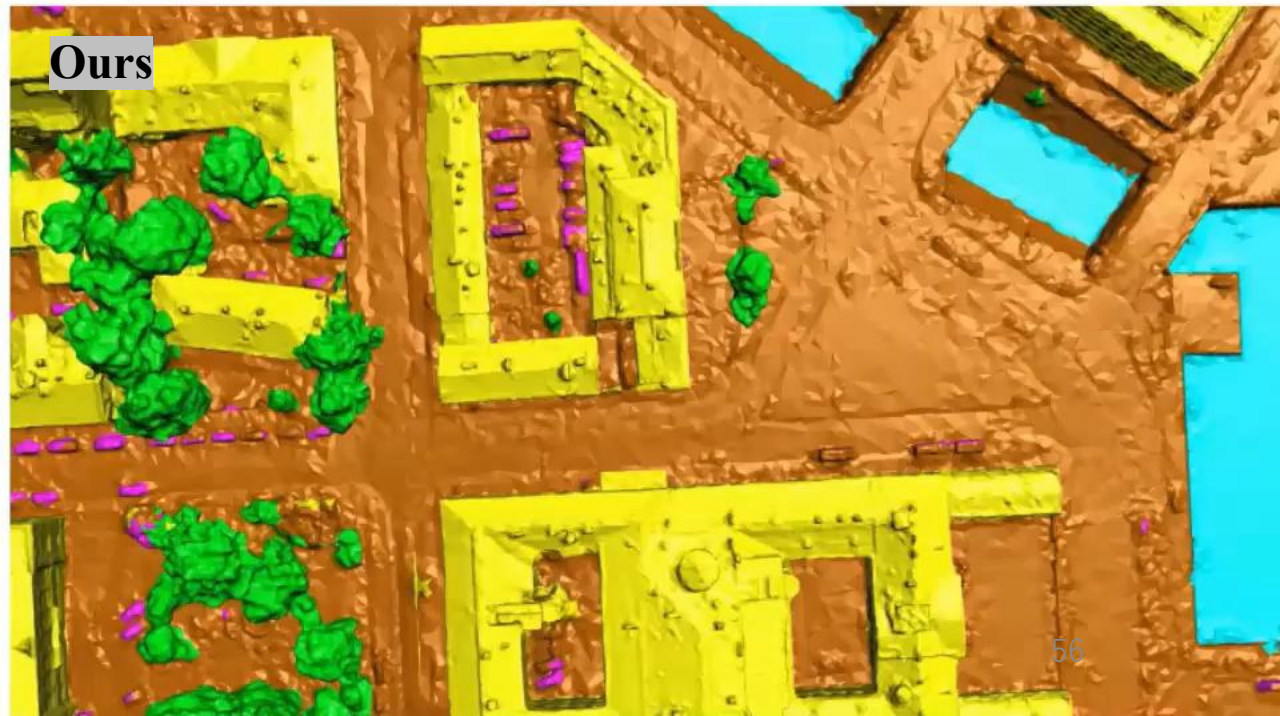
Ground truth



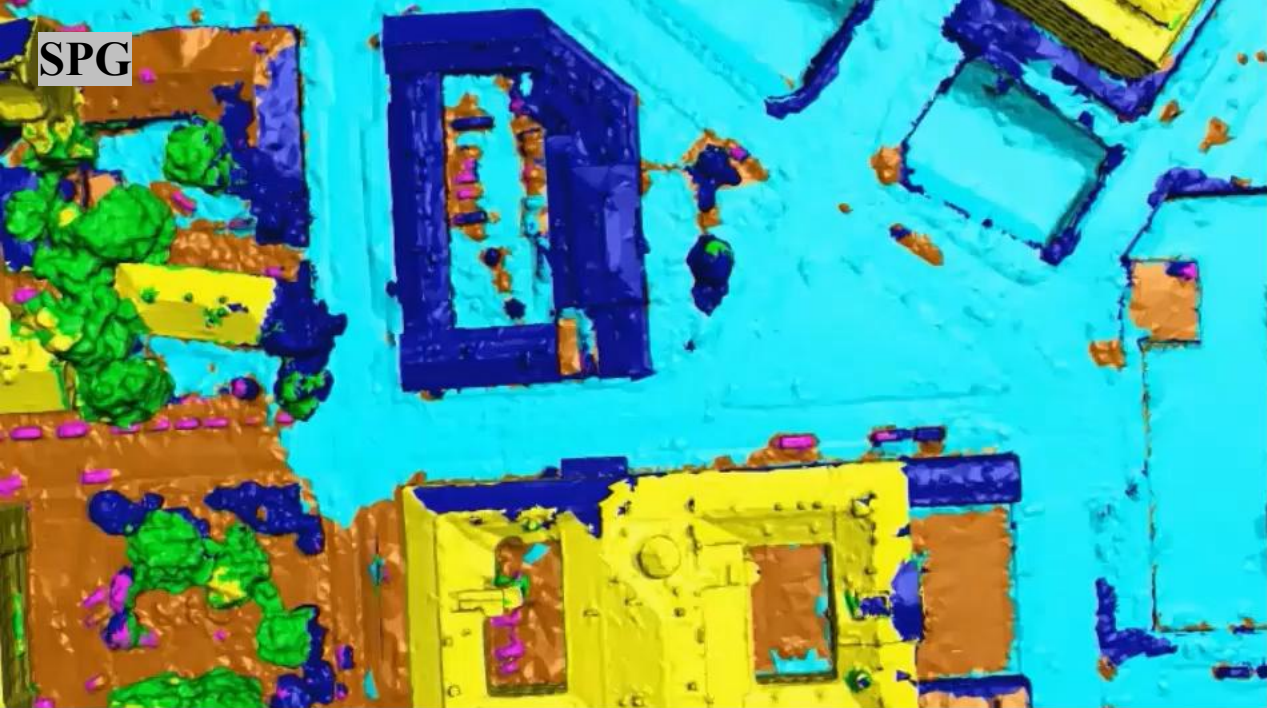
Error map



Ours



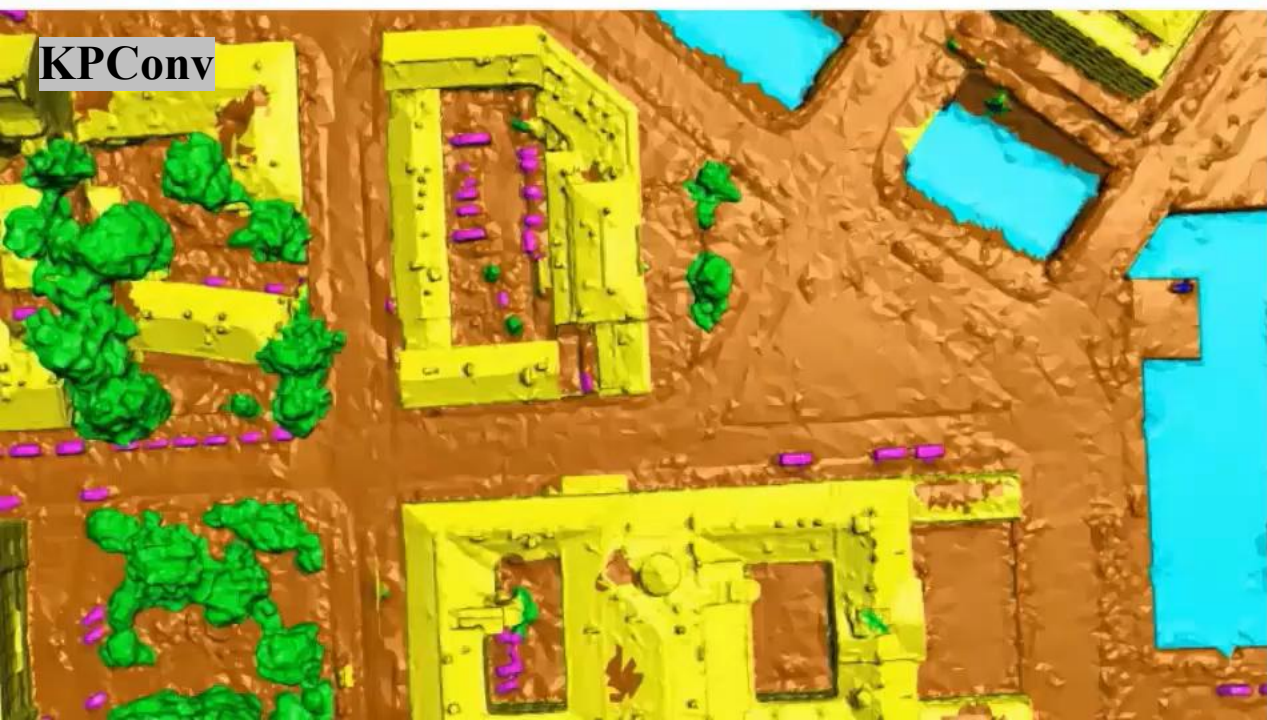
SPG



SUM-RF

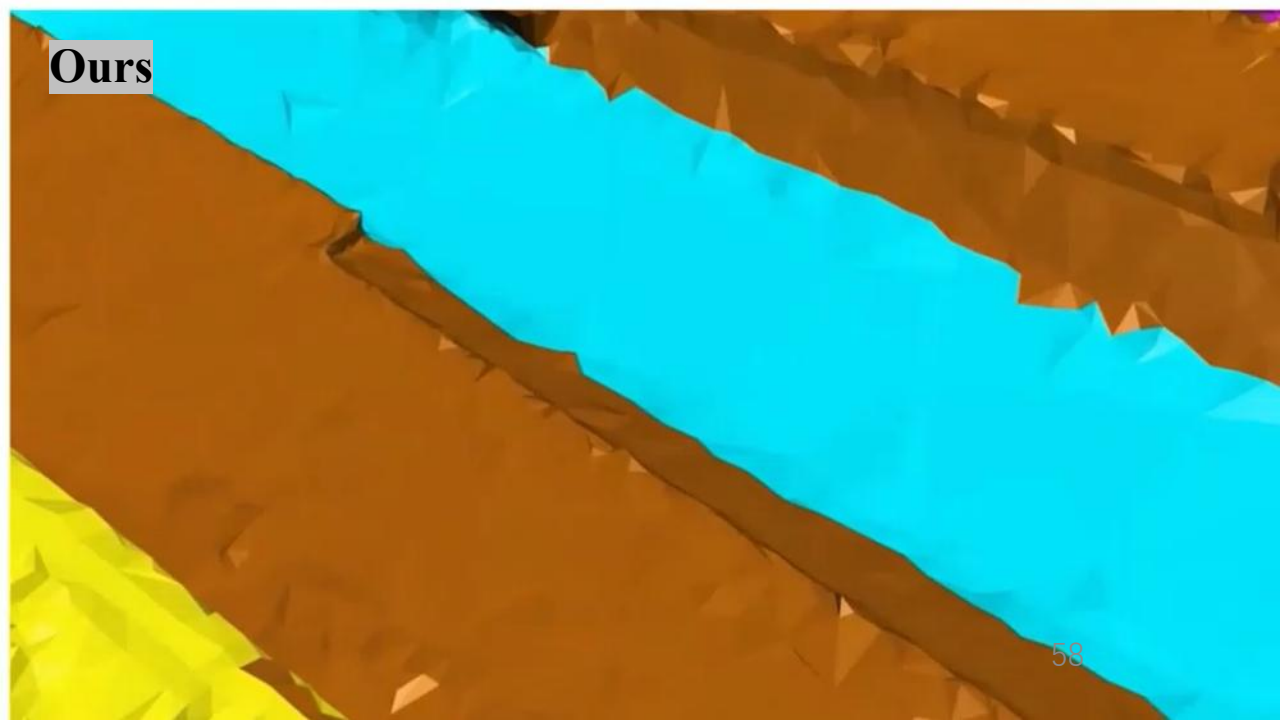
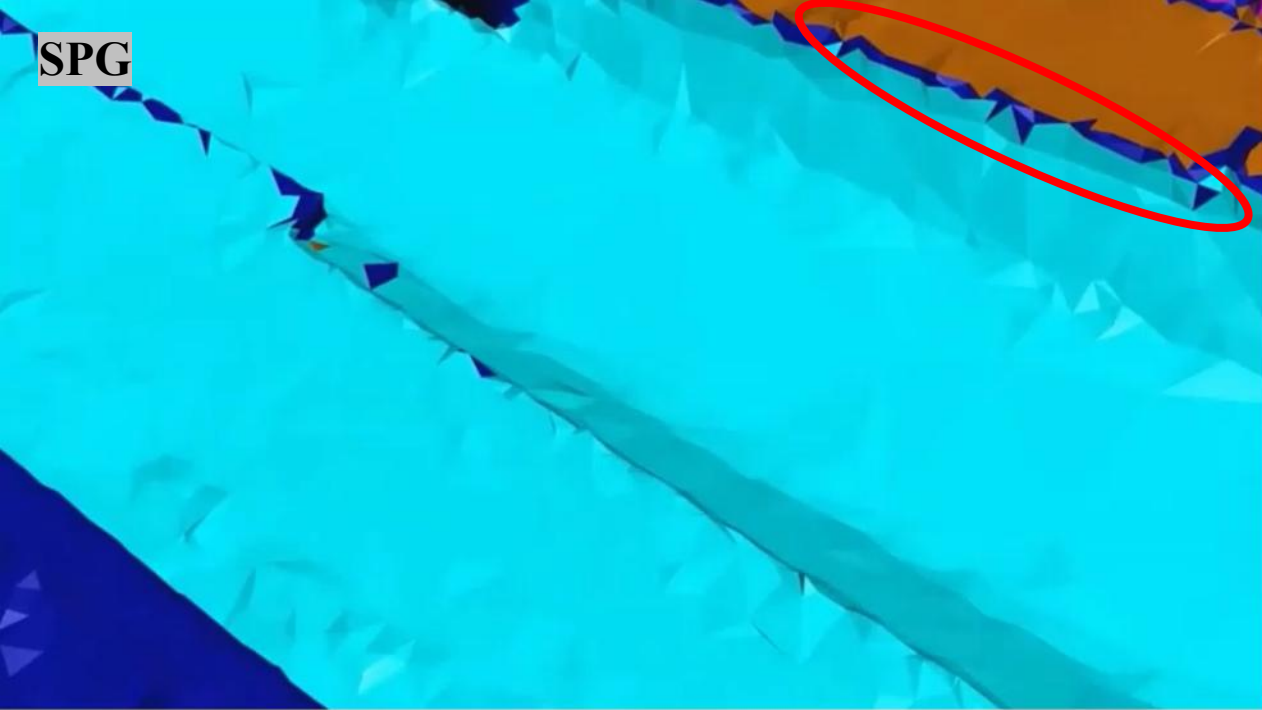


KPConv



Ours







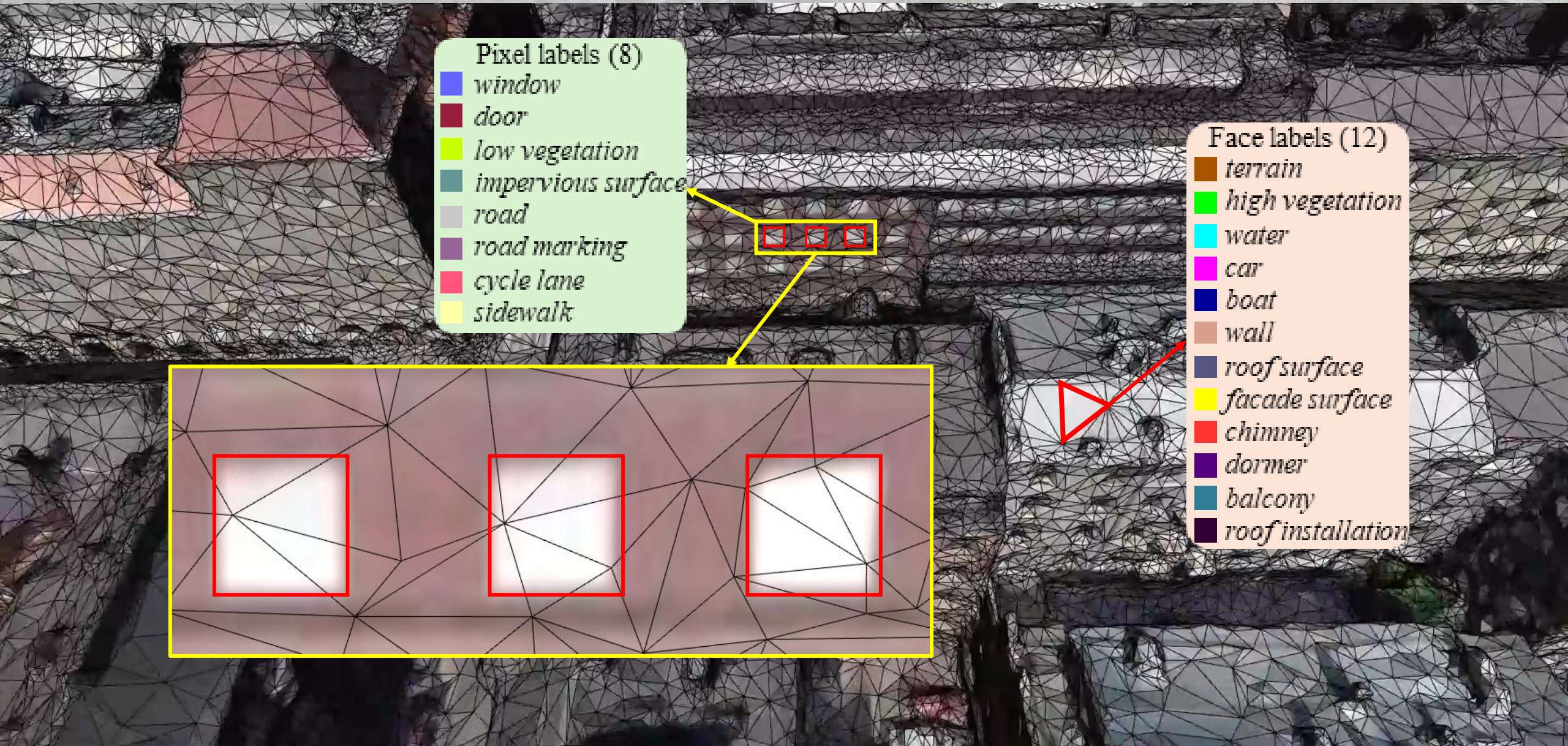
An aerial view of a city with a large, multi-story building complex highlighted in yellow and green. The building complex is situated on a peninsula or near a waterfront, with a road and a body of water visible. The surrounding city is shown in a faded, semi-transparent style. The text "4. Structure-aware interactive annotation" is overlaid on the image in a bold, black font.

4. Structure-aware interactive annotation

Motivation



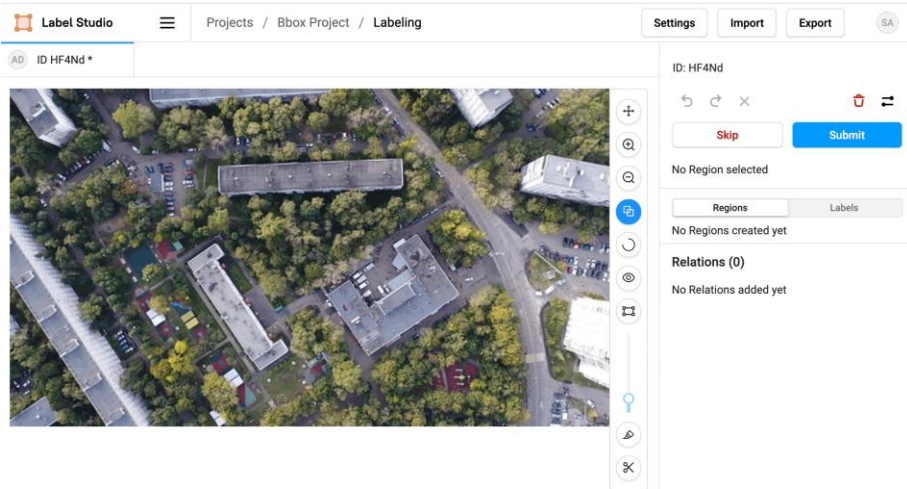
Semantic Understanding from Texture Meshes



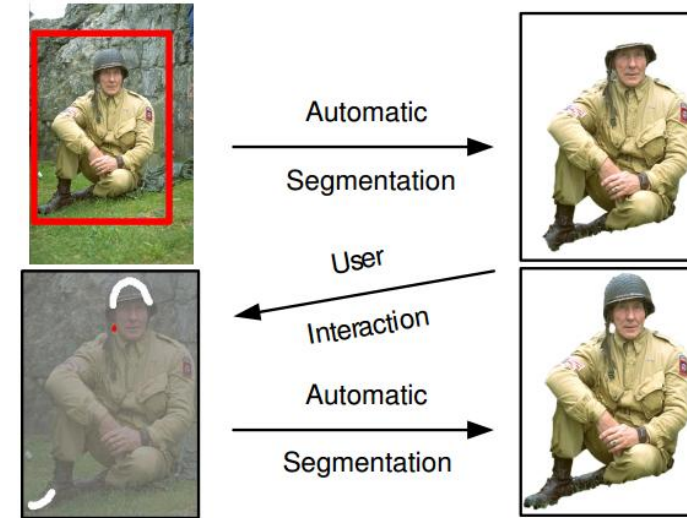
- Pixel labels (8)
- window
 - door
 - low vegetation
 - impervious surface
 - road
 - road marking
 - cycle lane
 - sidewalk

- Face labels (12)
- terrain
 - high vegetation
 - water
 - car
 - boat
 - wall
 - roof surface
 - facade surface
 - chimney
 - dormer
 - balcony
 - roof installation

Existing interactive image annotation



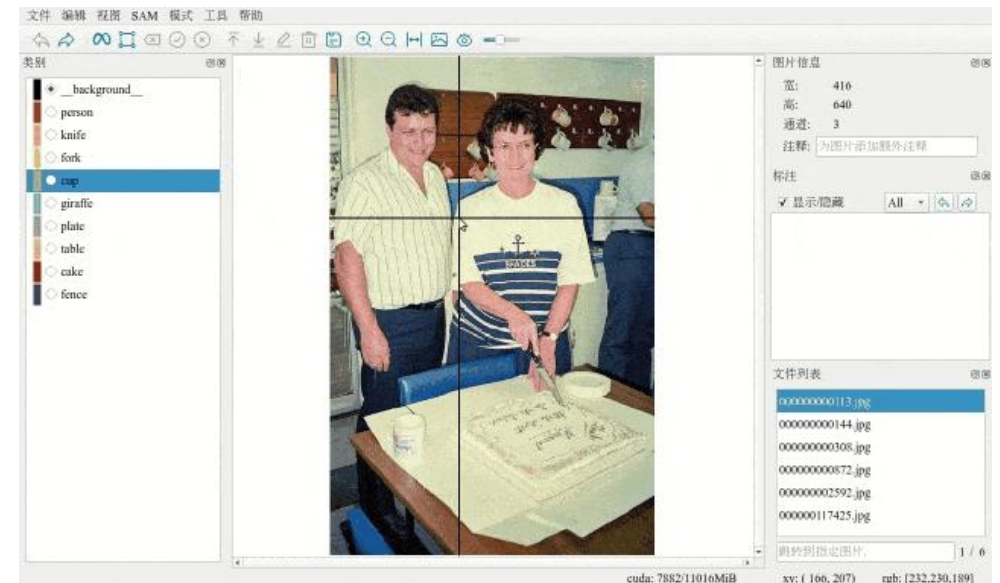
Manually labeling



Grabcut (Rother et al. 2004)

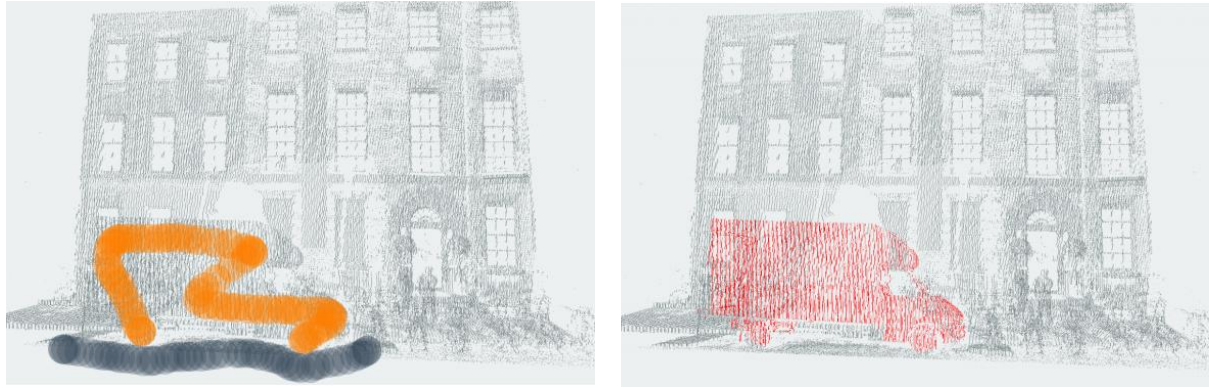


SimpleClick (Liu et al., 2023)

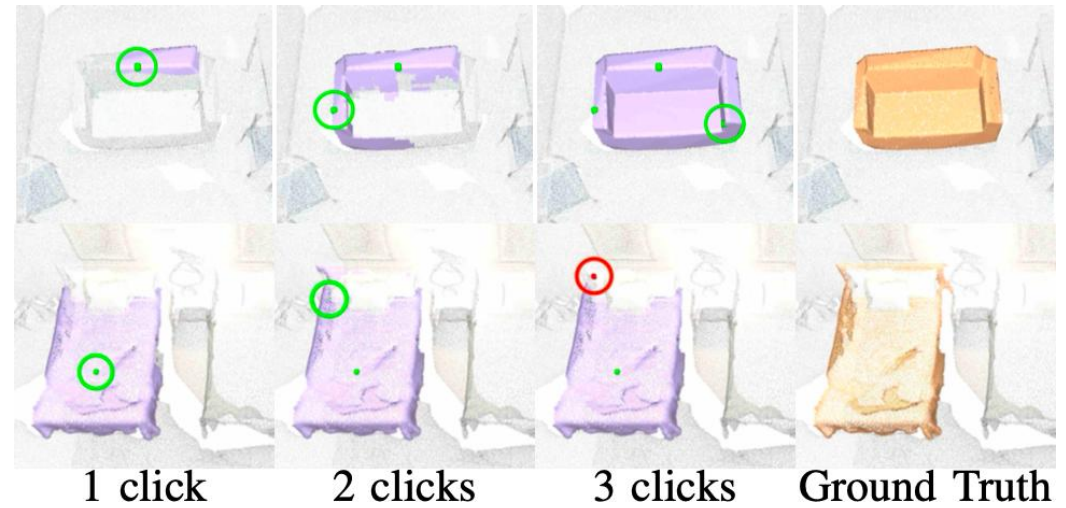


Segment Anything (Kirillov et al., 2023)

Existing interactive 3D annotation



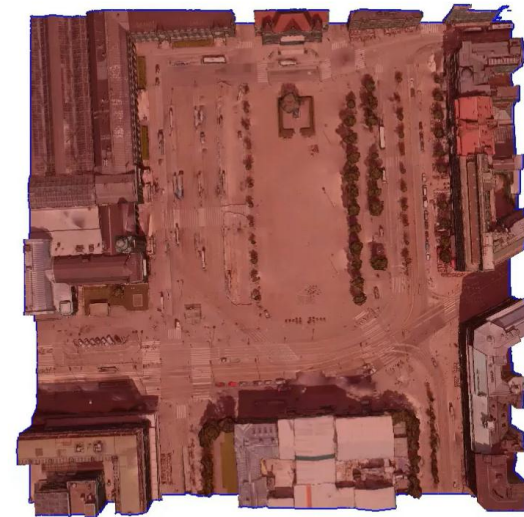
Graph cut-based (Liu et al. 2014)



Interactive object segmentation (Kontogianni et al. 2023)

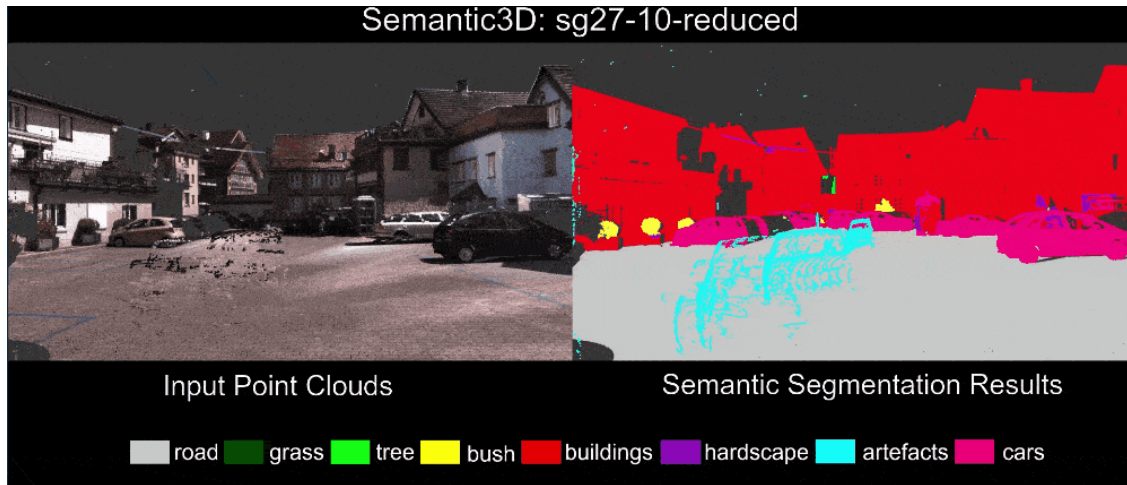


AGILE3D (Yue et al. 2024)



Segment-based mesh annotation (Gao et al. 2021)

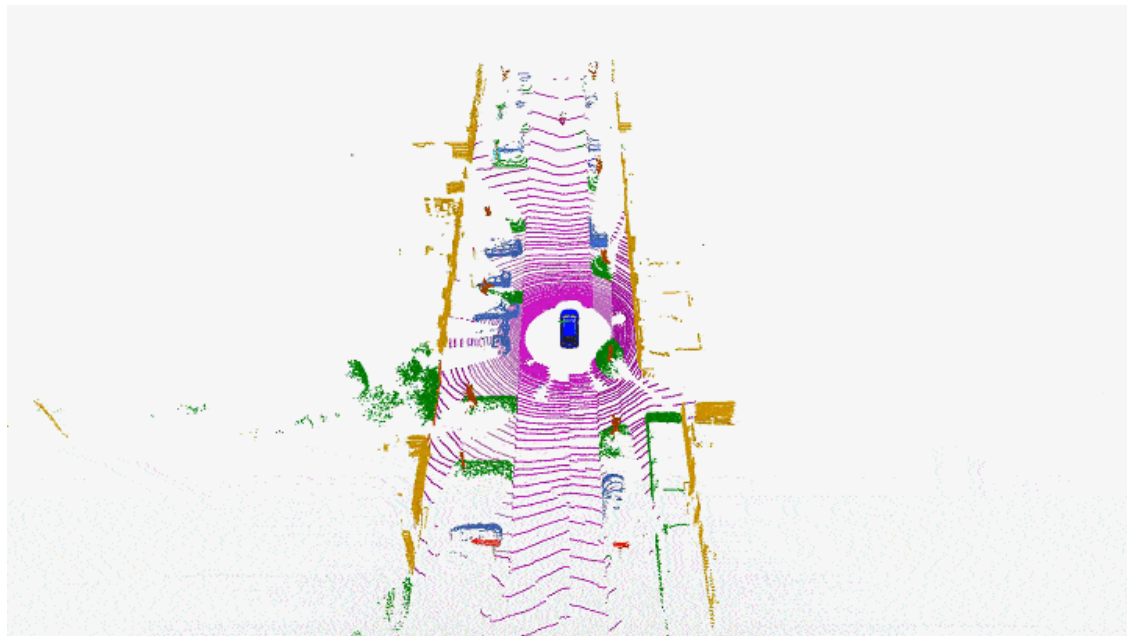
Existing semantic 3D urban datasets



Semantic3D (Hackel et al. 2017)



SensatUrban (Hu et al. 2022)

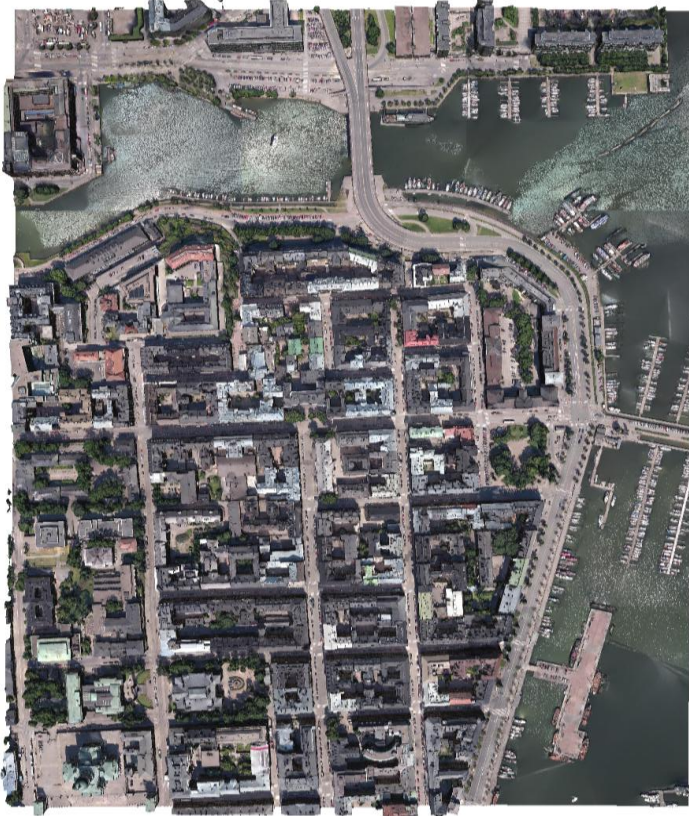


SemanticKITTI (Jens et al. 2019)



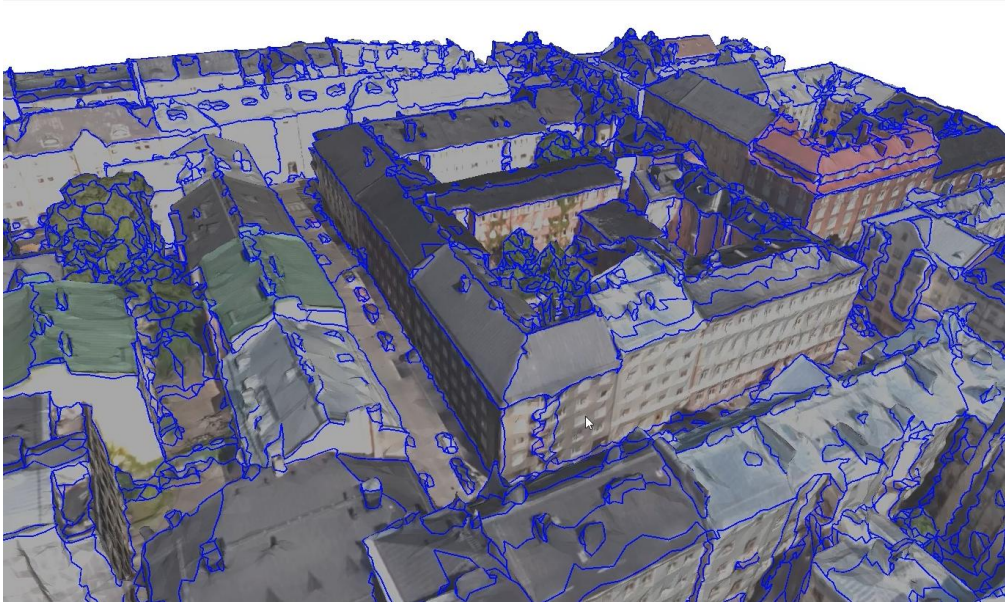
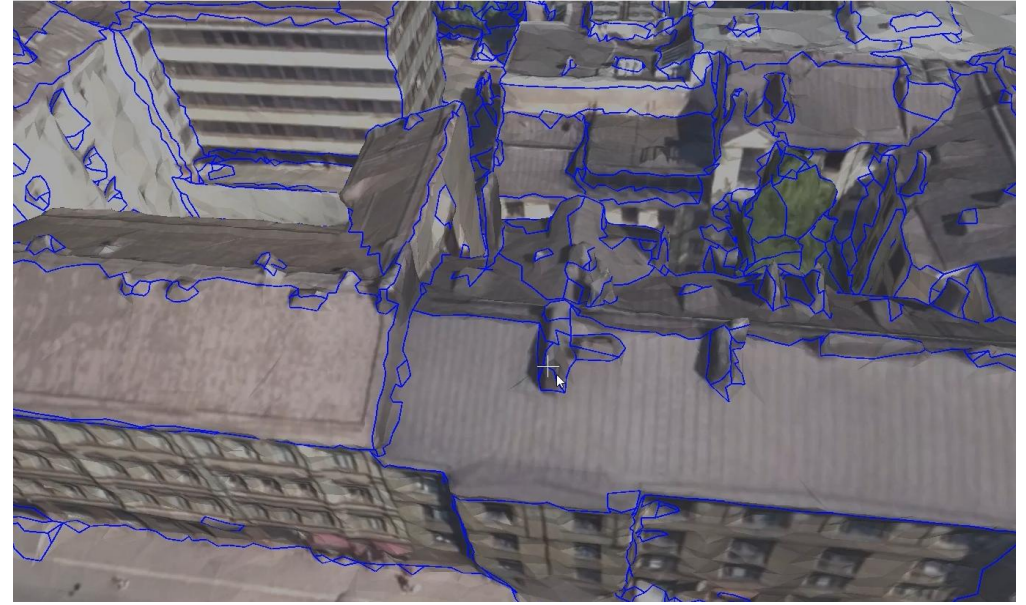
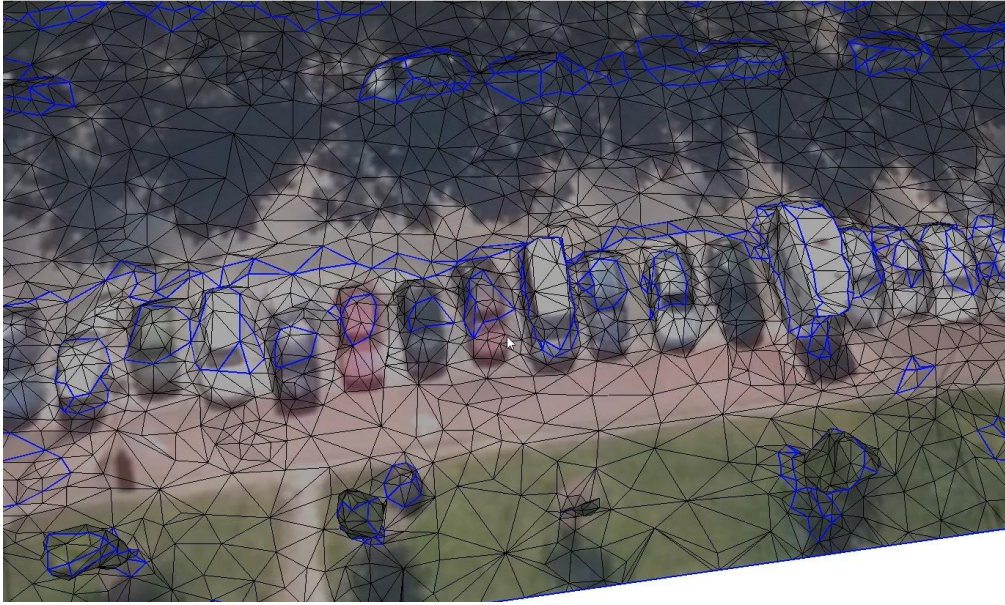
Semantic urban mesh benchmarks (Gao et al. 2021)⁶⁵

Our SUM parts dataset



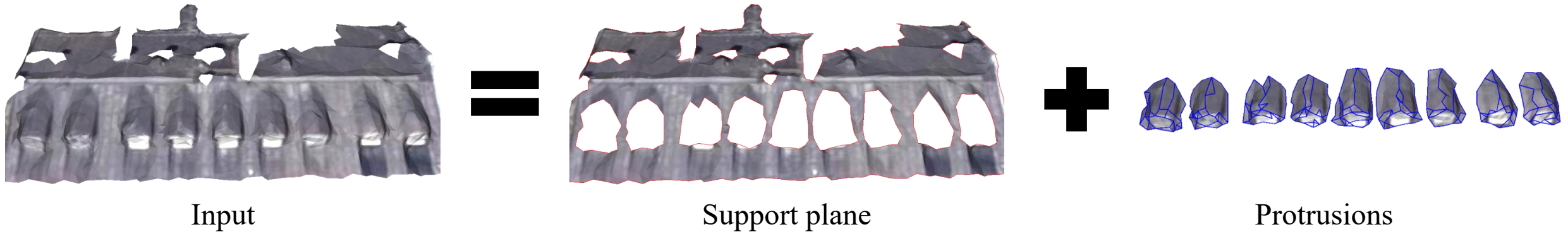
- Covering approximately **2.5 km²** across **three** representative locations in central Helsinki.

Face-based annotation - problems



Segment-based mesh annotation (Gao et al. 2021)

Face-based annotation - Interactive 3D selection

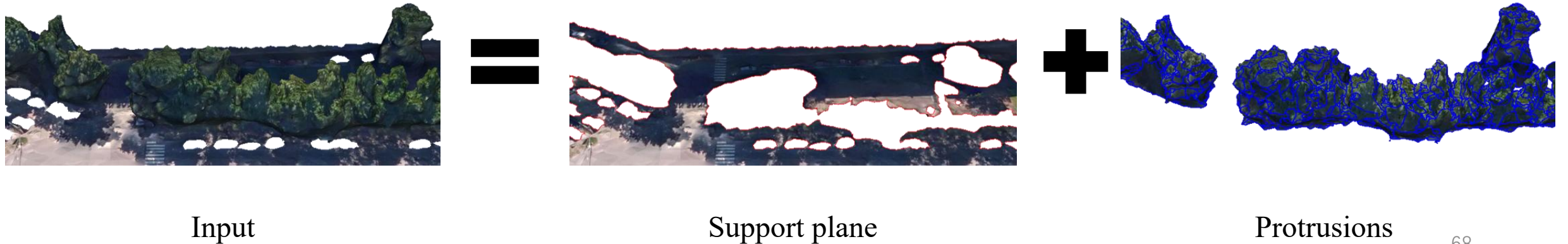


Distance d_i

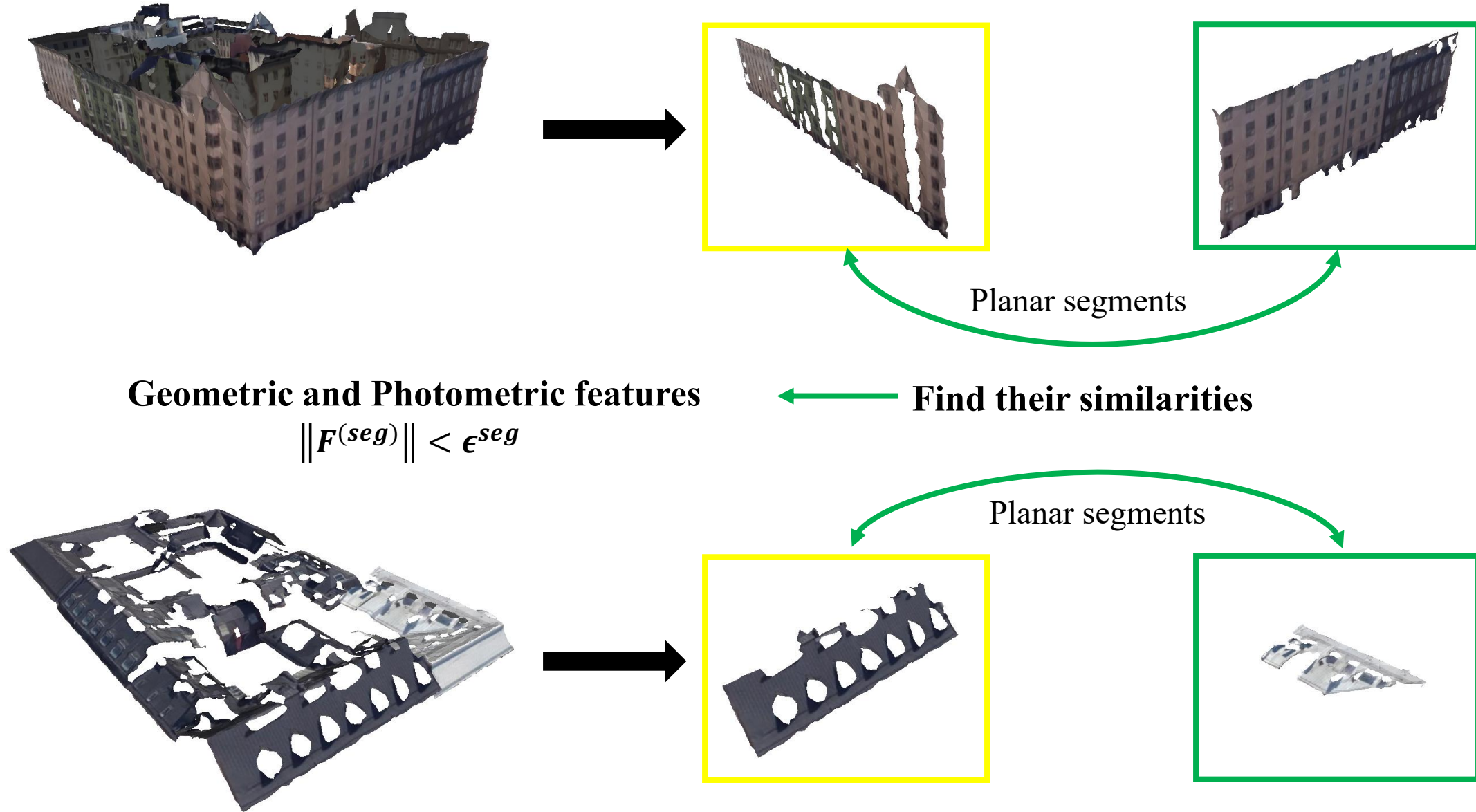
Angle ω_i

Local geometric consistency $R_{i,j}$

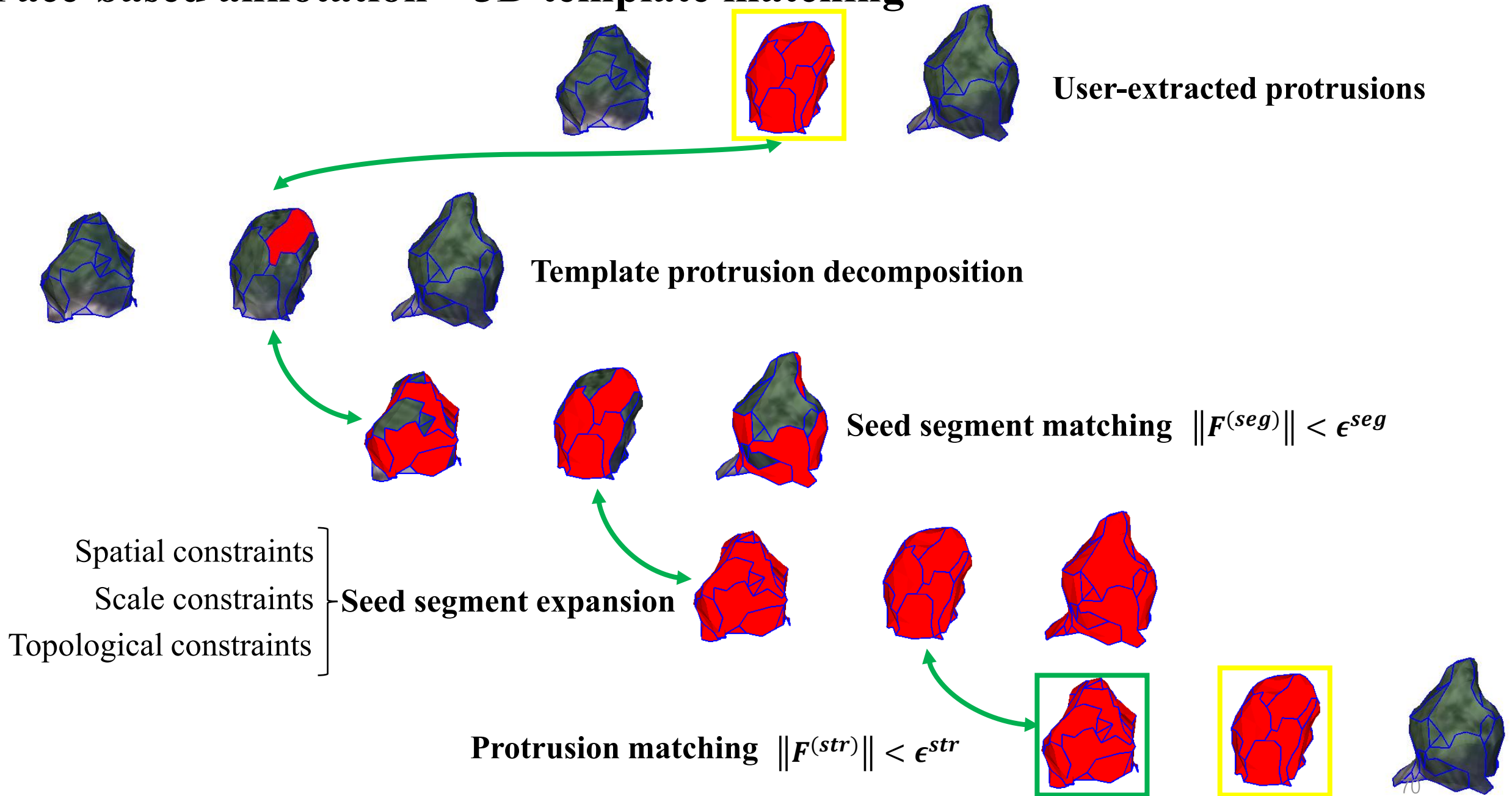
Find their differences



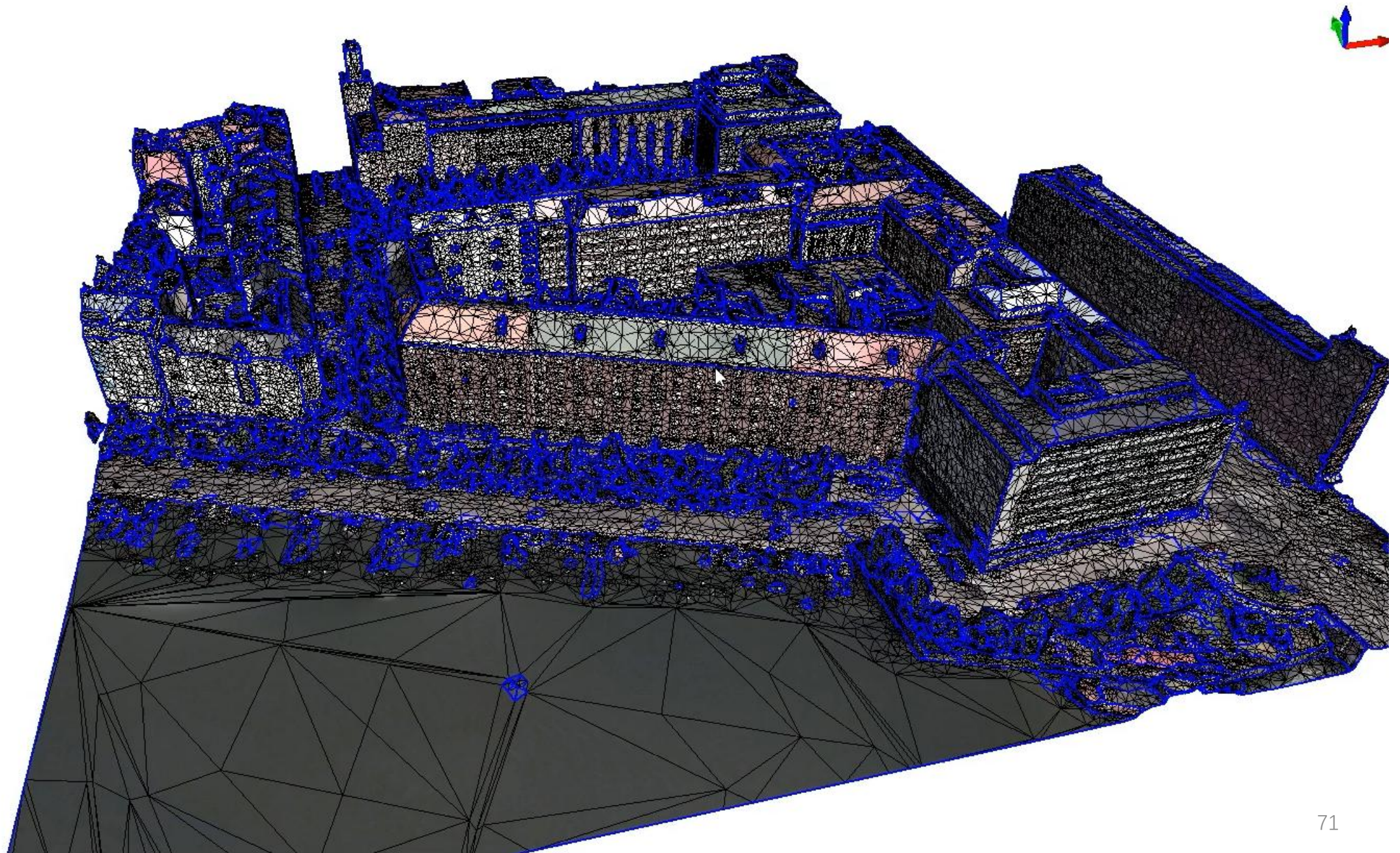
Face-based annotation – 3D template matching



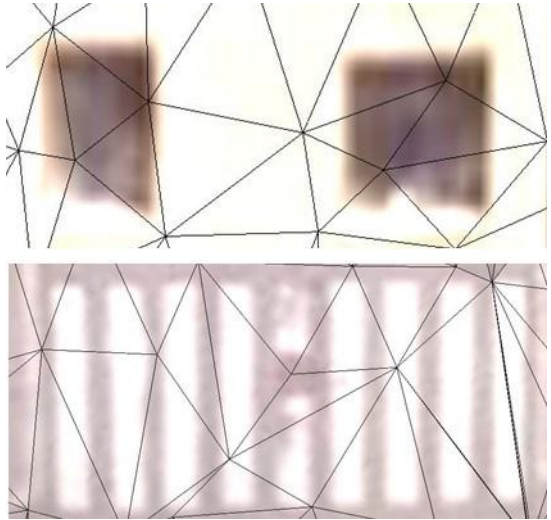
Face-based annotation – 3D template matching



Face-based annotation - demo



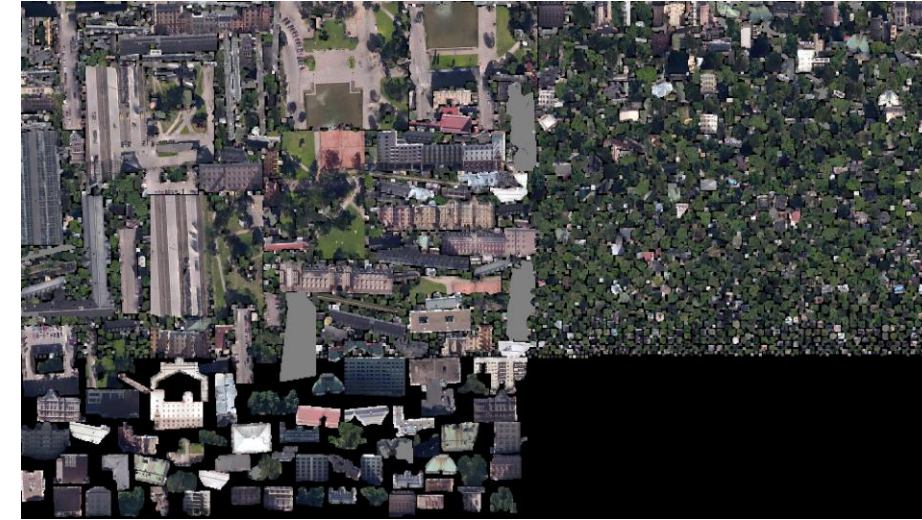
Texture-based annotation - problems



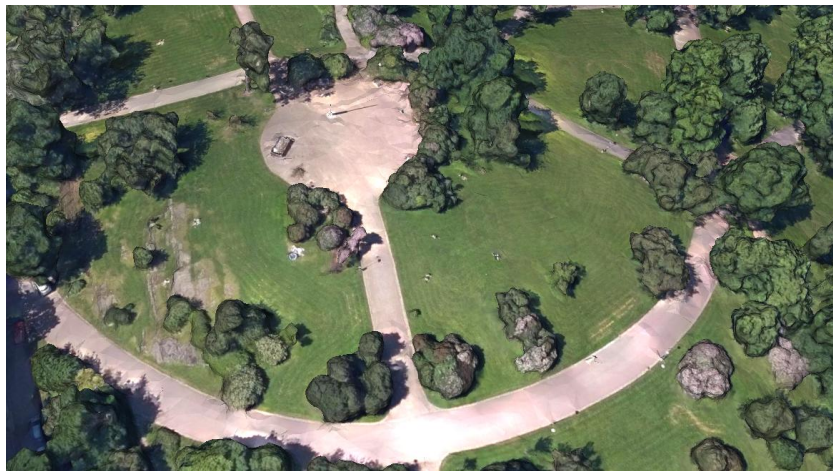
Richer details than triangles



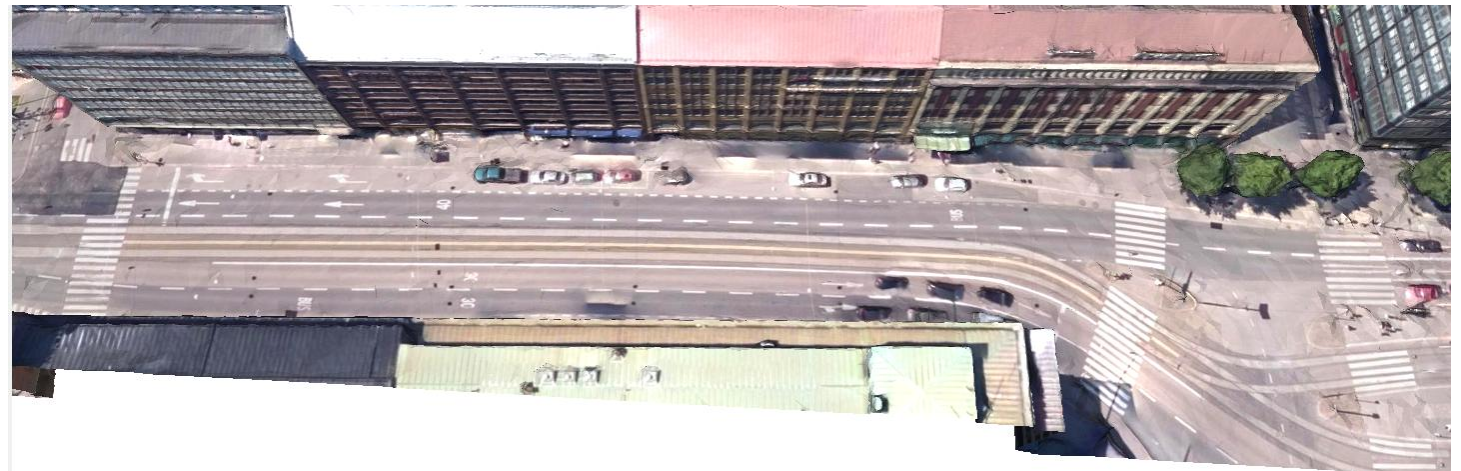
Direct 3D texture labeling involves numerous inefficient 2D-3D conversions



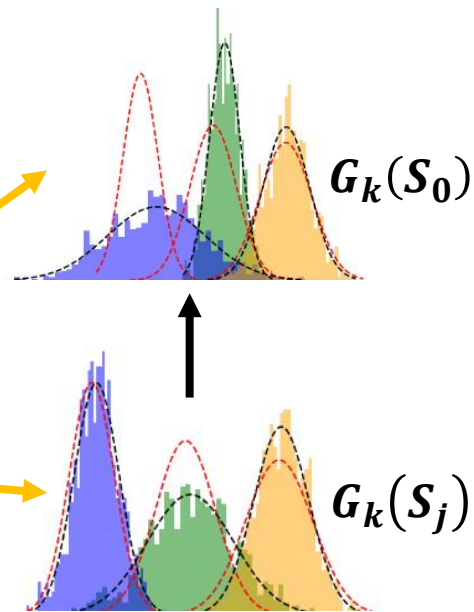
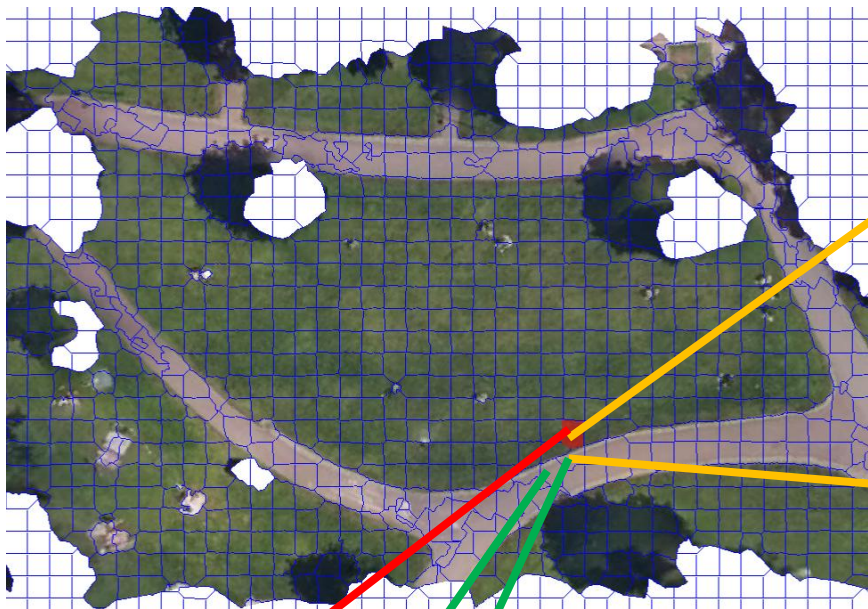
Directly labeling small texture segments in 2D texture images is challenging



Contains objects with complex boundaries and numerous repetitive regular structures, making labeling work burdensome.

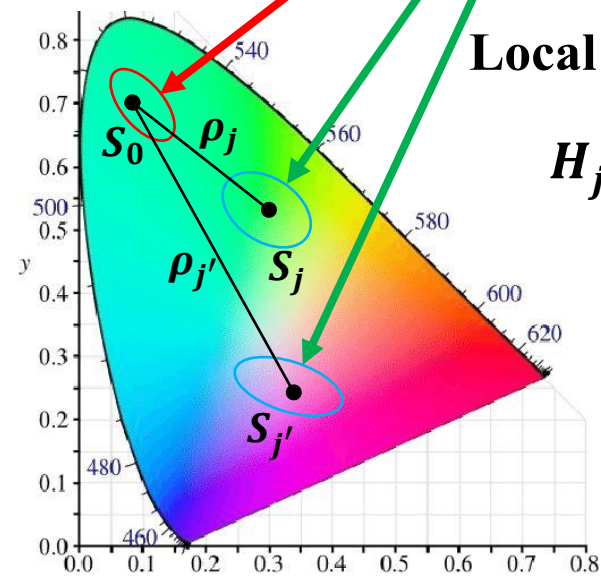
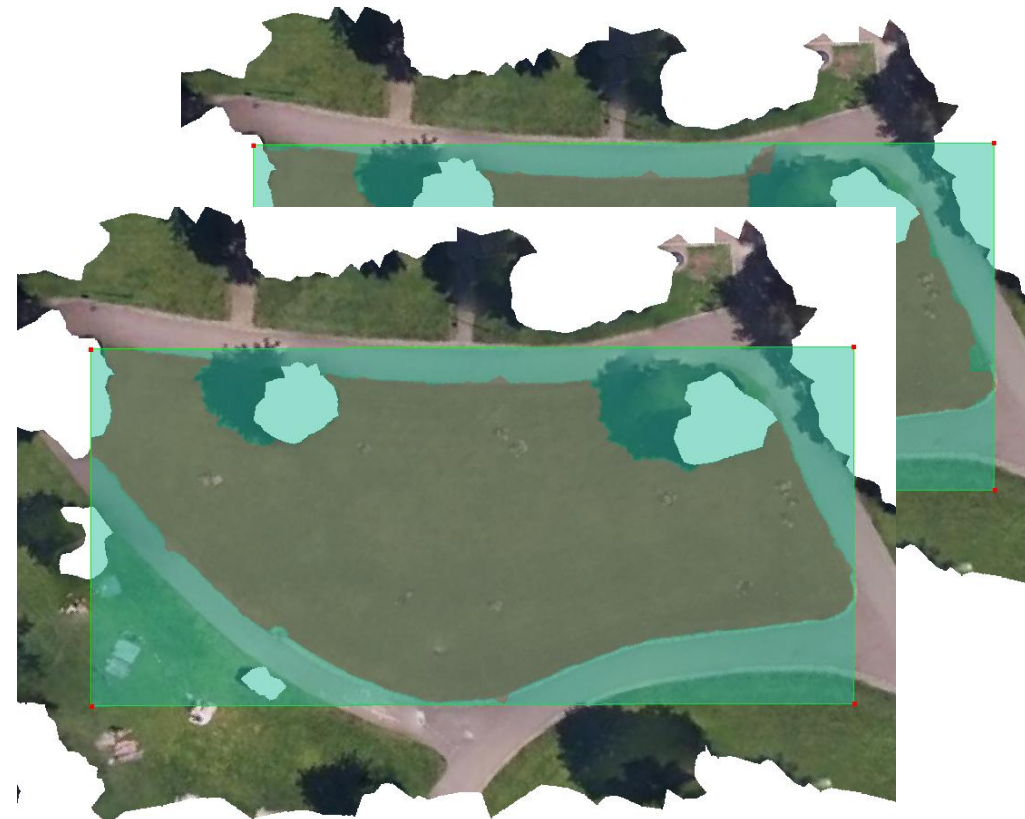


Texture-based annotation – Interactive 2D selection



Wassertein distance

$$w_j = \frac{1}{3} \sum_{k=1}^3 W(G_k(S_j), G_k(S_0))$$



Local color

$$H_{jj'} =$$

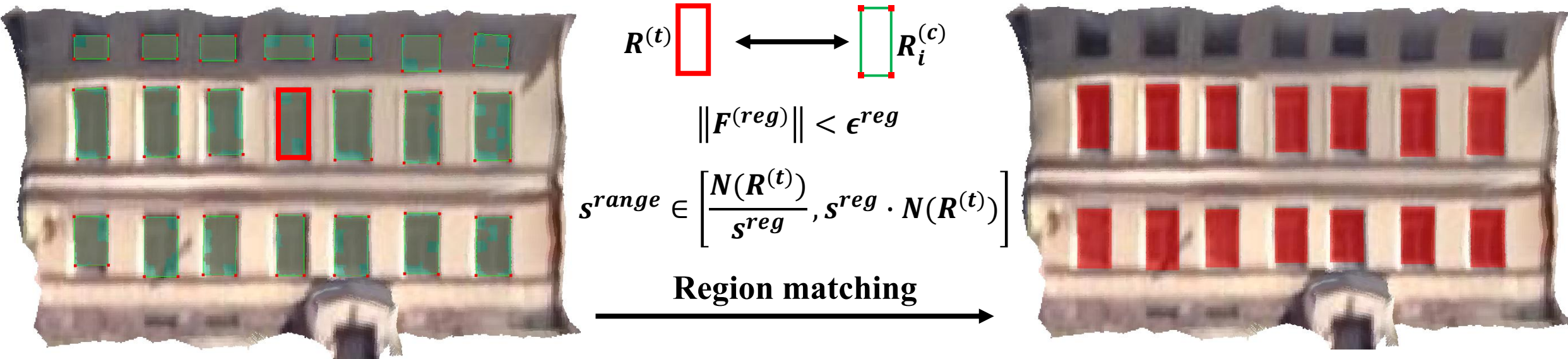
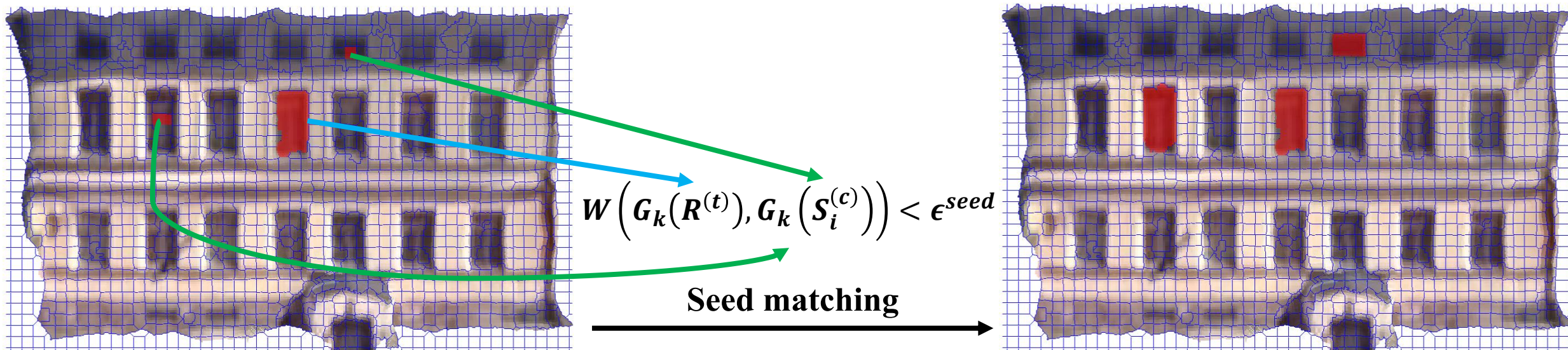


- Foreground
- Background
- Unknown
- Bounding box

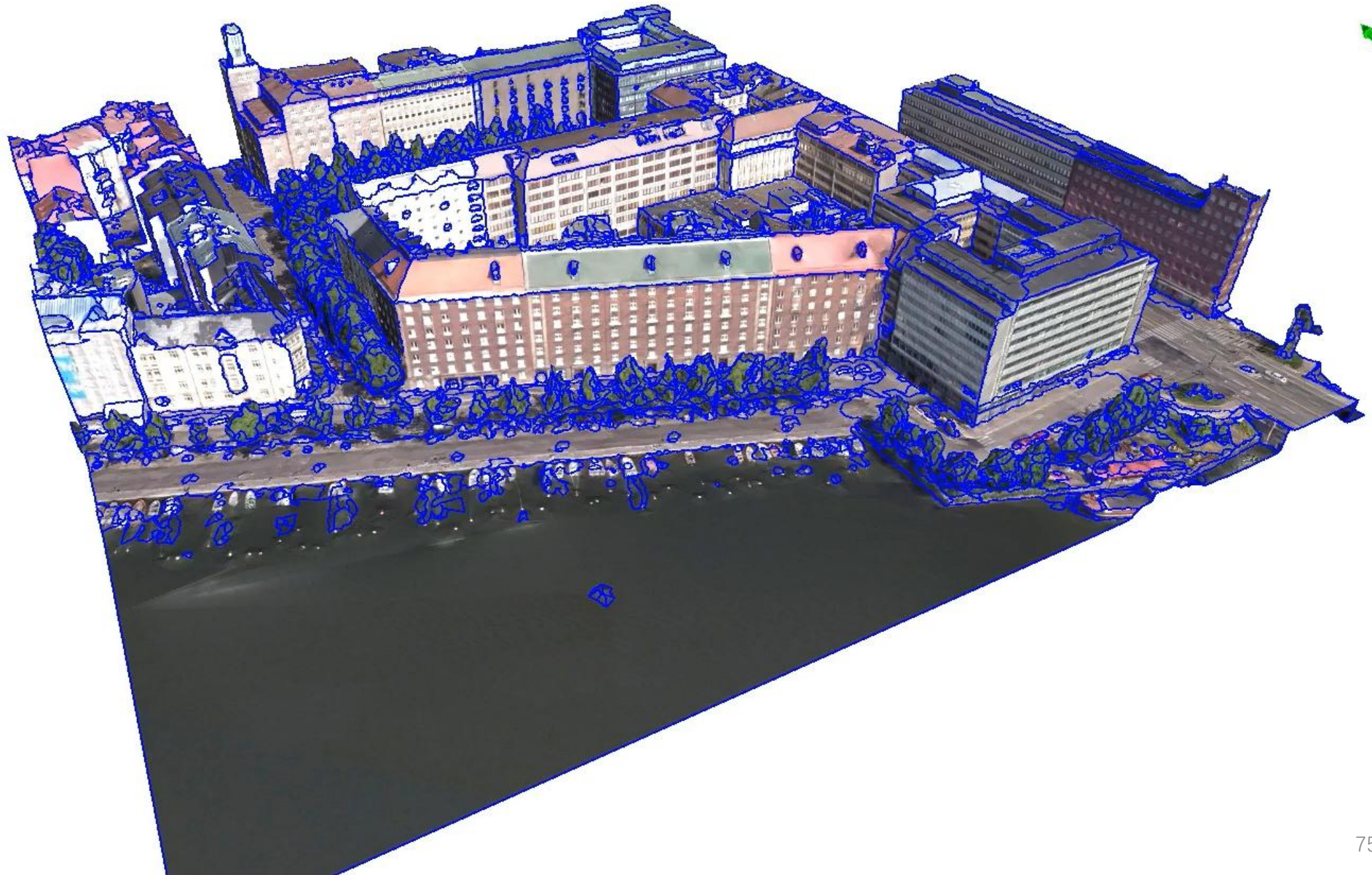
Fine segmentation

CIEDE2000 distance: $\rho_j, \rho_{j'}$

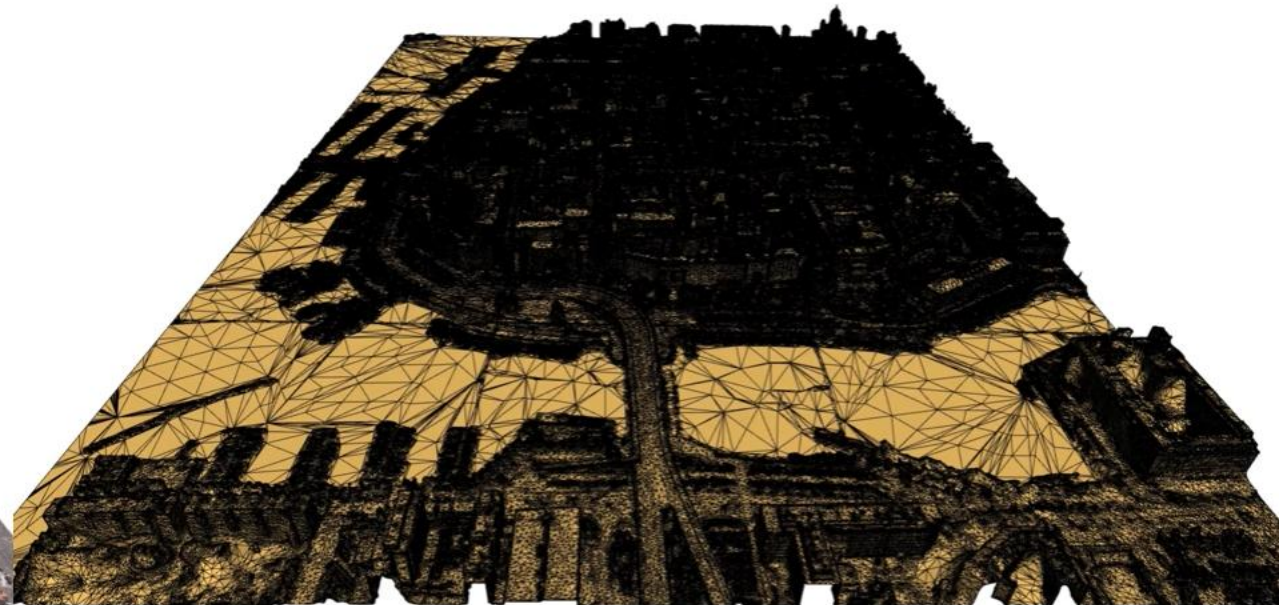
Texture-based annotation – 2D template matching



Texture-based annotation - demo



Annotation results

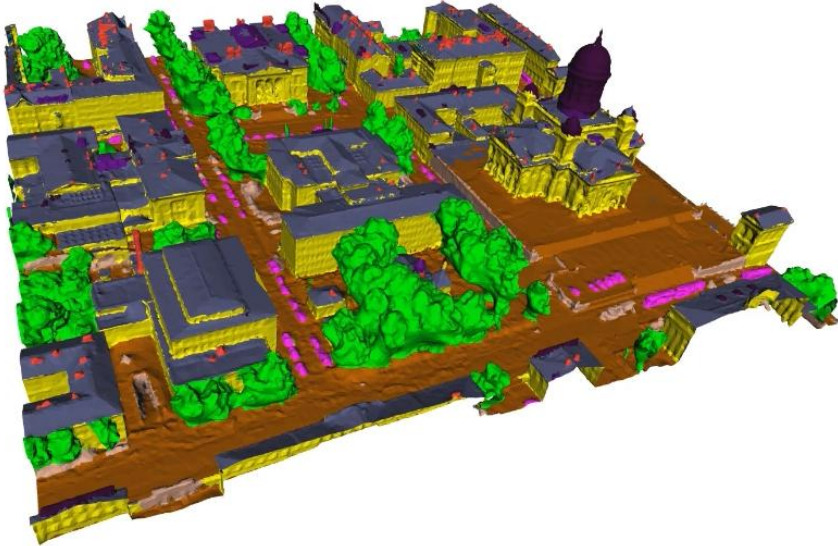


Evaluation of semantic segmentation – face label

Textured mesh



PointNext



PointVector



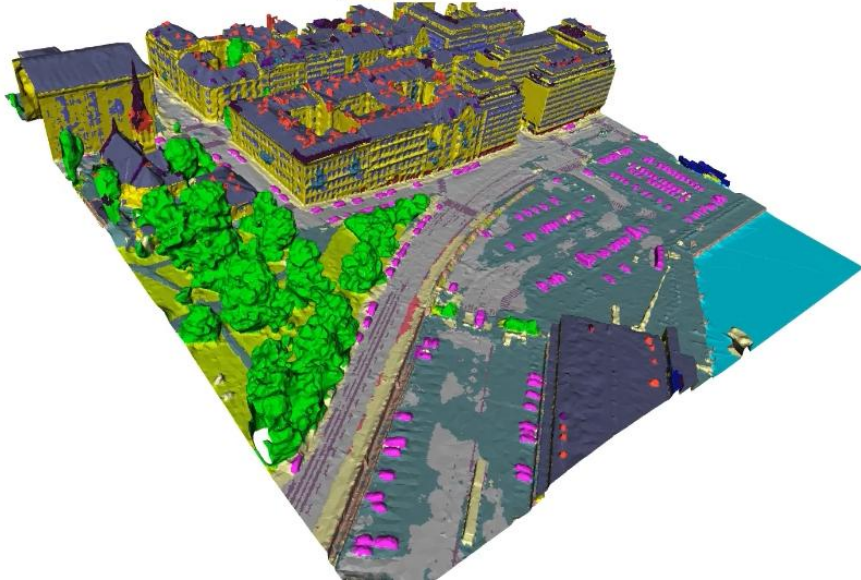
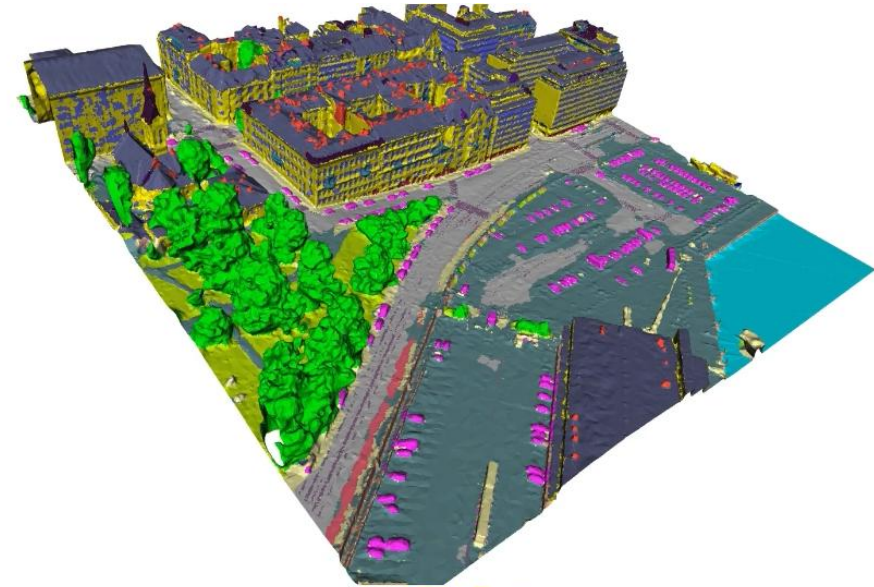
Ground truth

Evaluation of semantic segmentation – pixel label

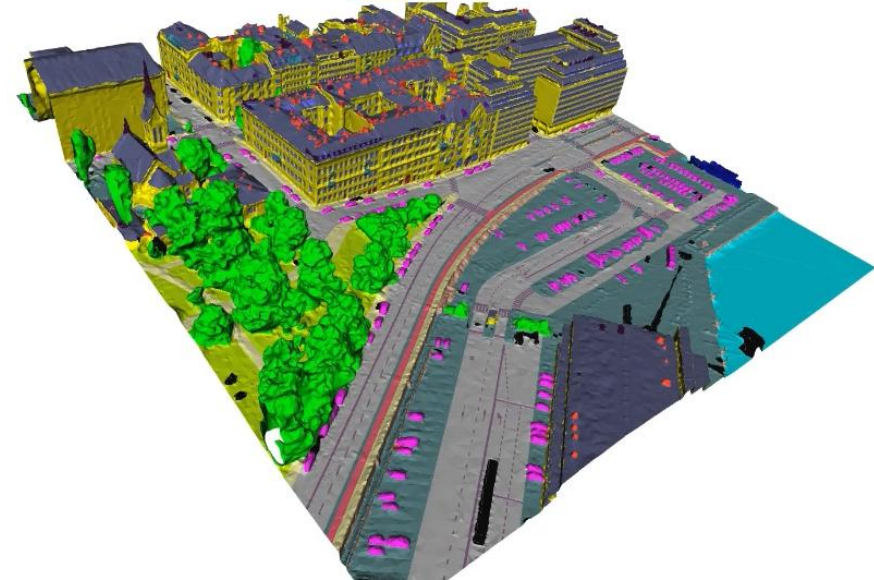
Textured mesh



PointNext

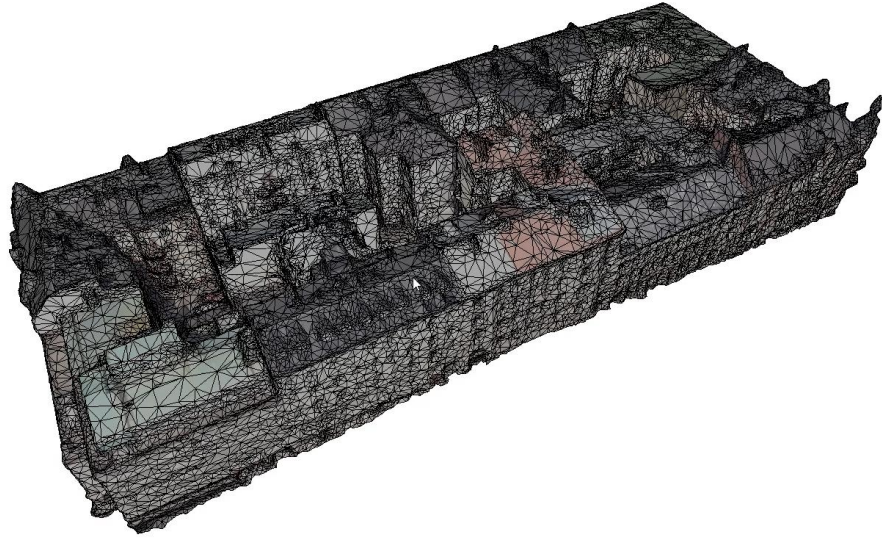


PointVector

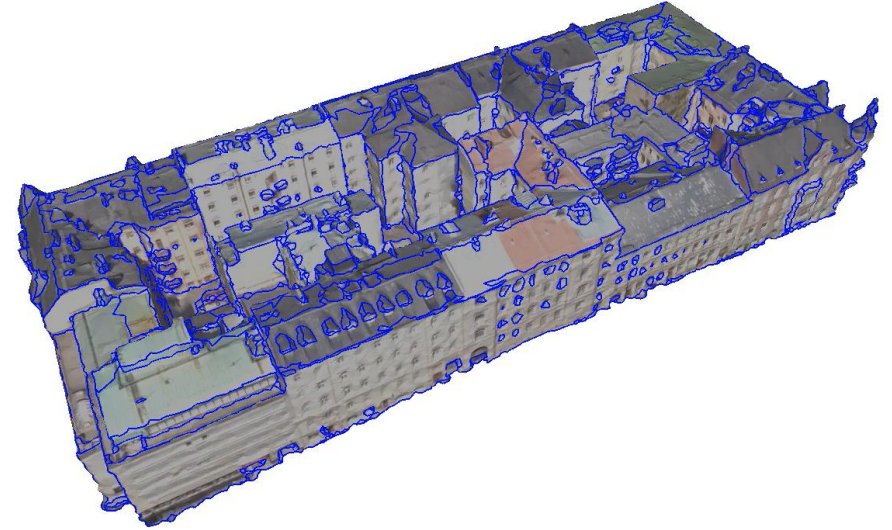


Ground truth

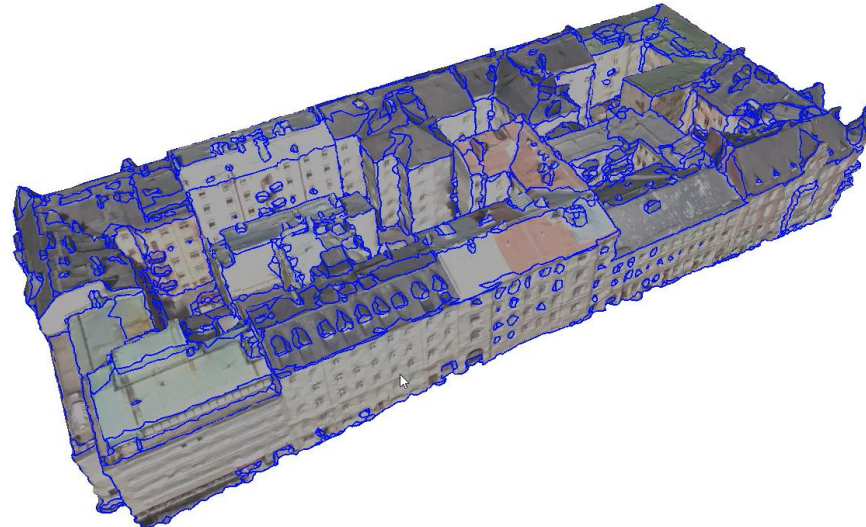
Evaluation of interactive face annotation



Manually annotation



Segment-based annotation



Our annotation

Evaluation of interactive texture annotation



Grabcut



Simple click

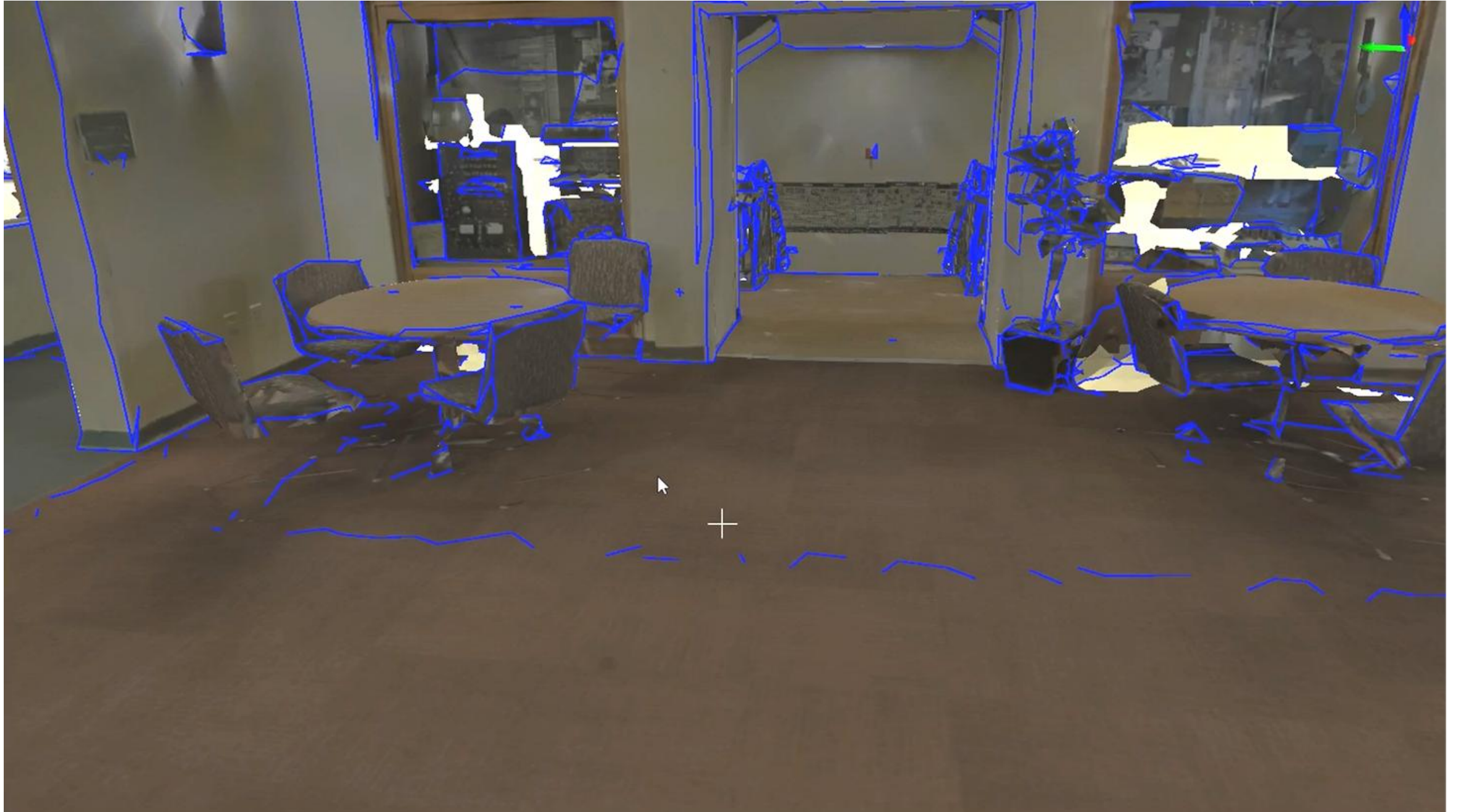


Segment Anything



Our annotation

Annotation tool applications

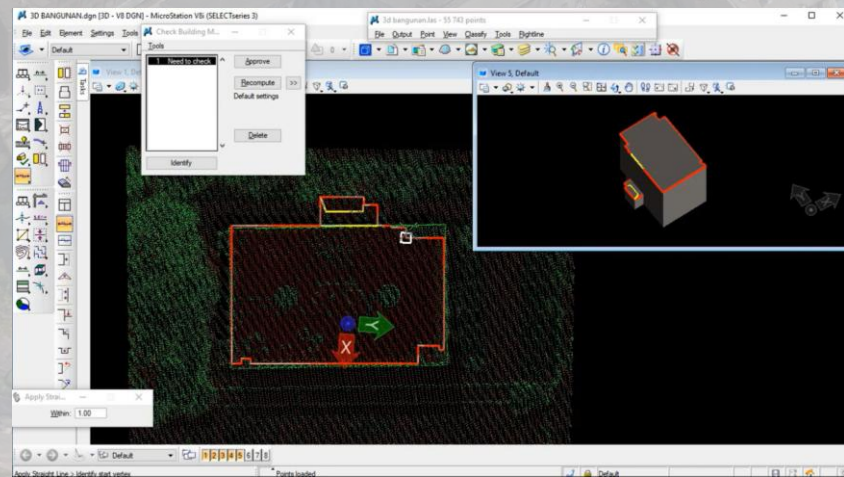


An aerial view of a city with a 3D reconstruction overlay. The reconstruction is semi-transparent, showing a grid of buildings in yellow and blue, with green trees and pink/purple markers on the roofs. The background shows a dense urban area with various building styles, a river, and a road. The text "5. Lightweight 3D city model reconstruction" is centered over the image.

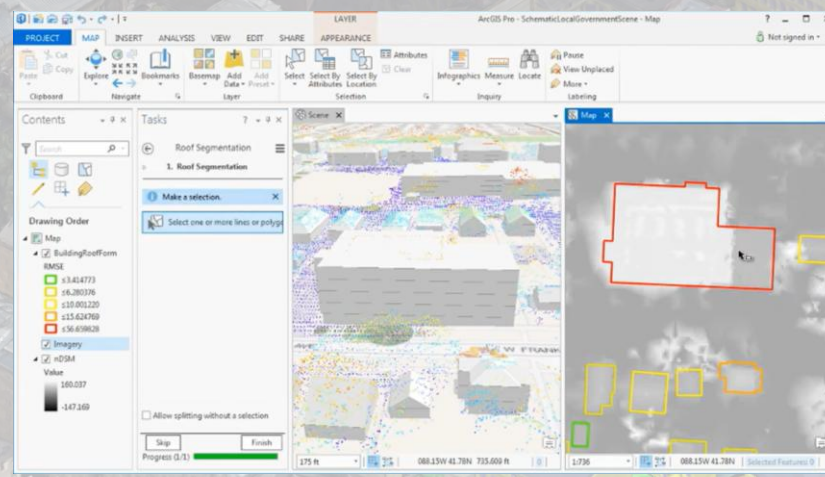
5. Lightweight 3D city model reconstruction

Manual Vectorization (3D Modeling)

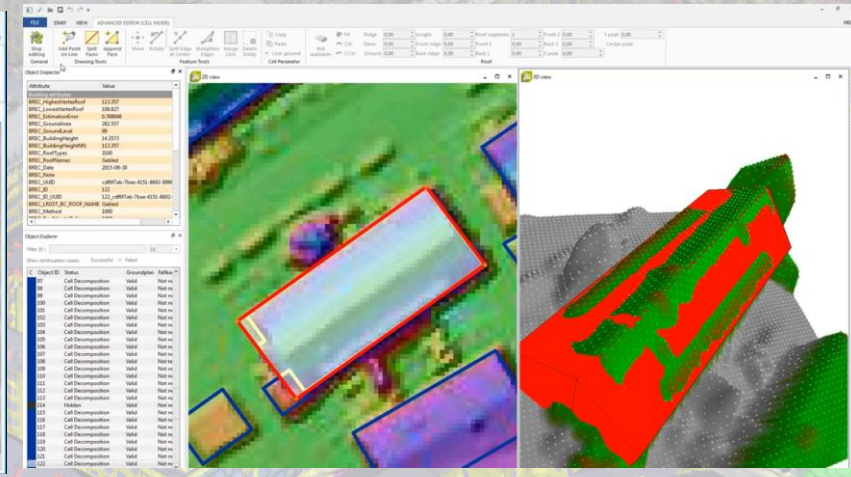
Point Cloud-Based Manual Vectorization



Bentley Systems

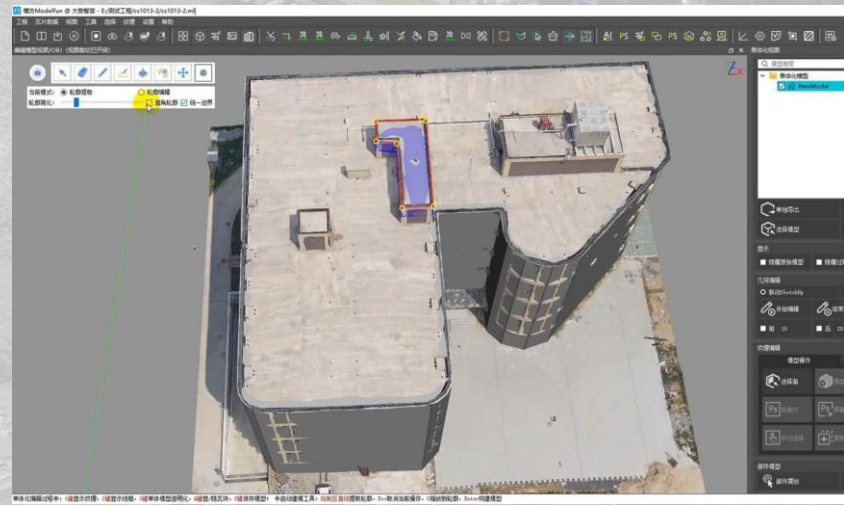


ESRI

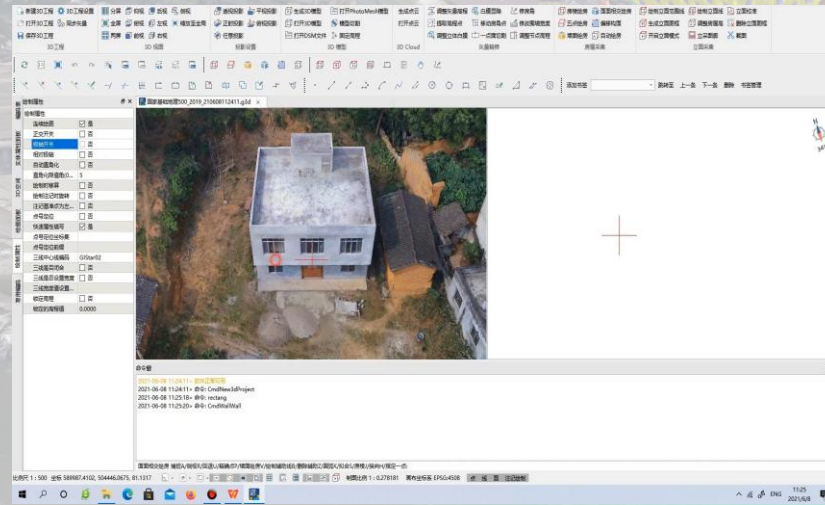


Virtual City Systems

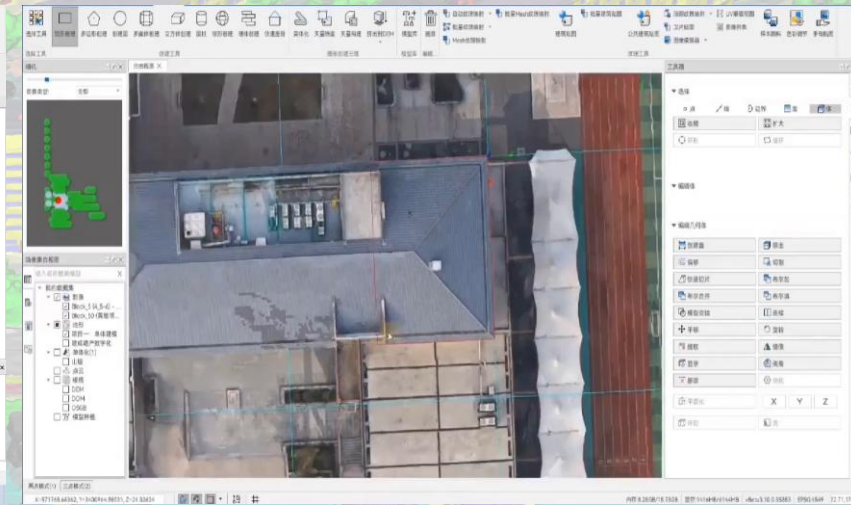
Textured Mesh-Based Manual Vectorization



Daspatial Technology

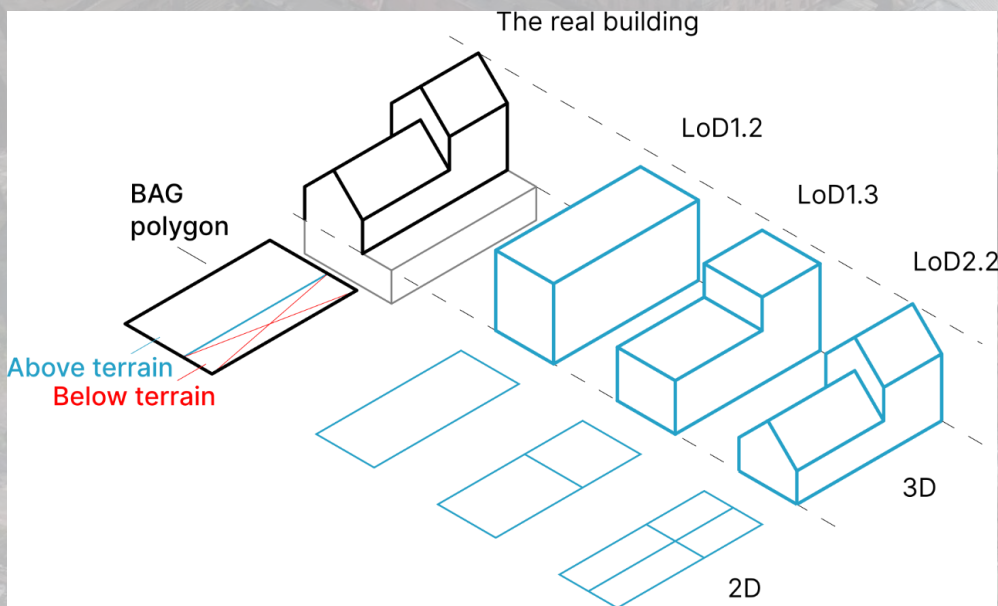


South Survey

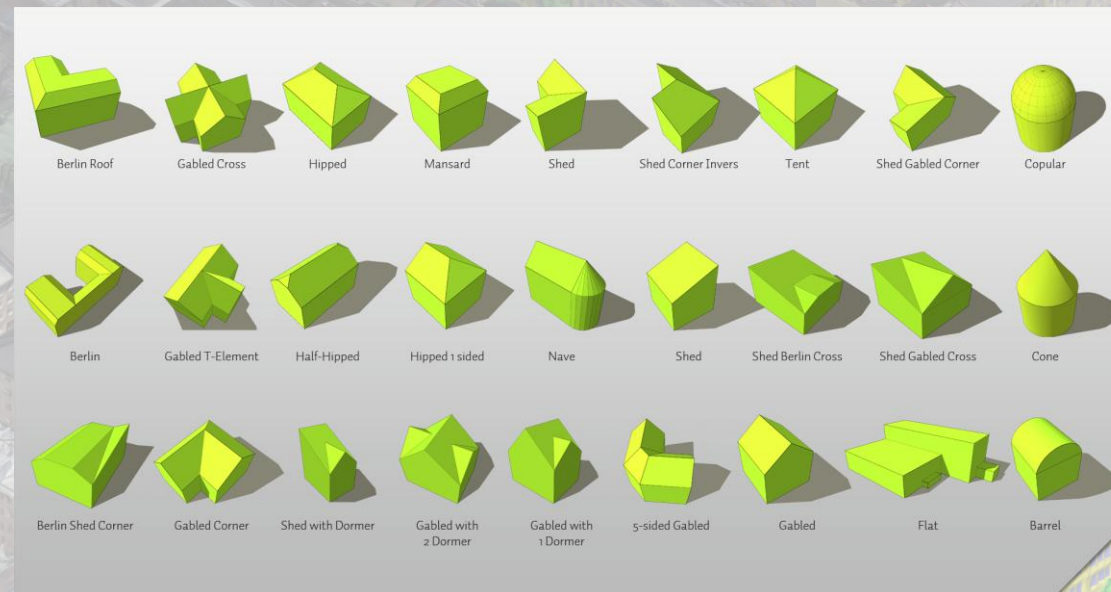


Tianjihang Technology

Automatic Vectorization (3D Reconstruction)

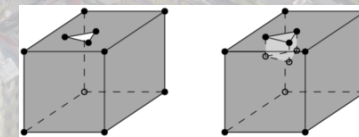


2D Extrusion

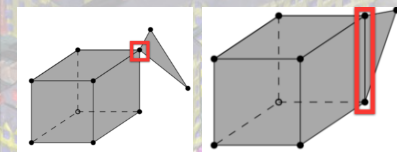


Template Matching

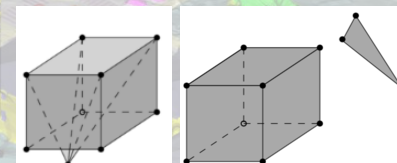
Topological Errors



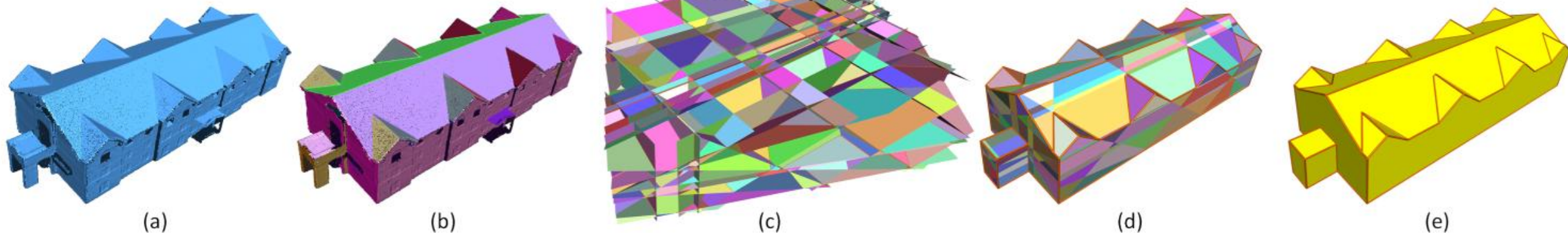
Holes



Non-manifolds

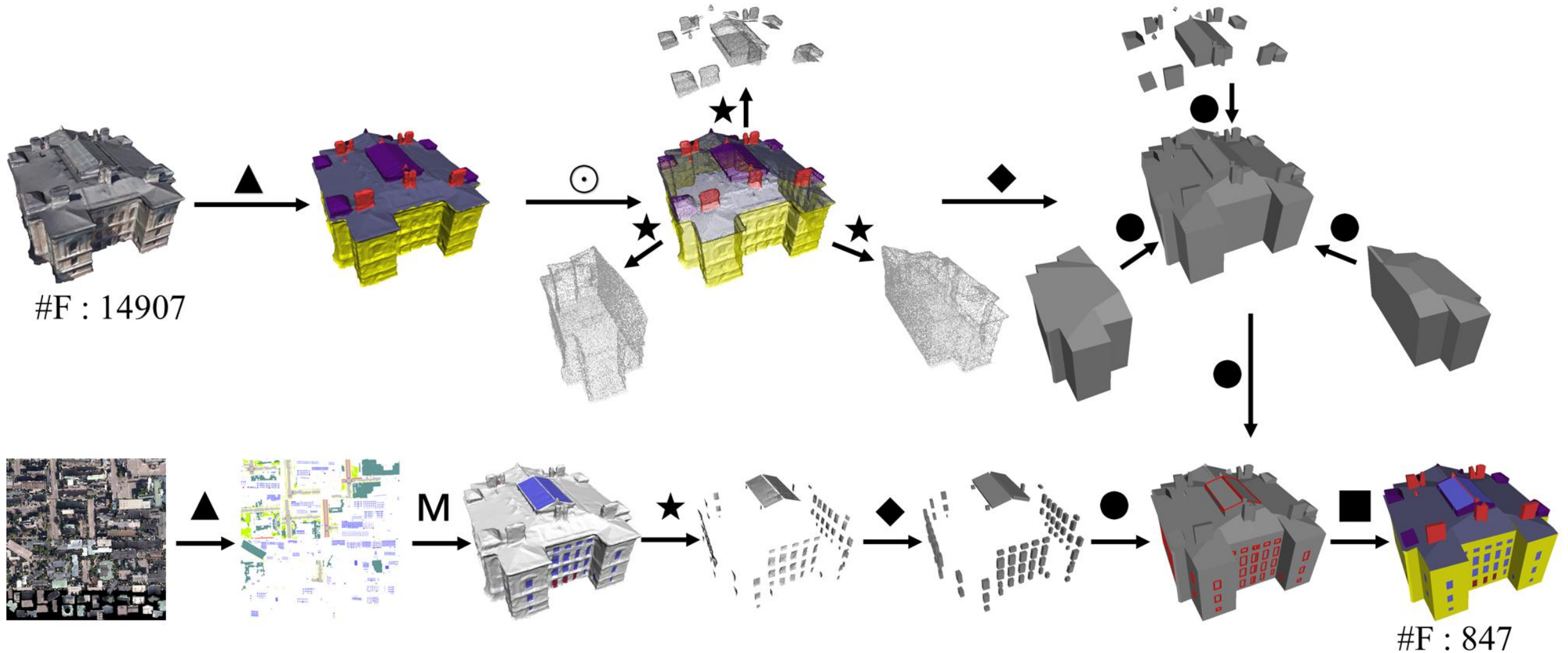


Self-intersections & Multiple components



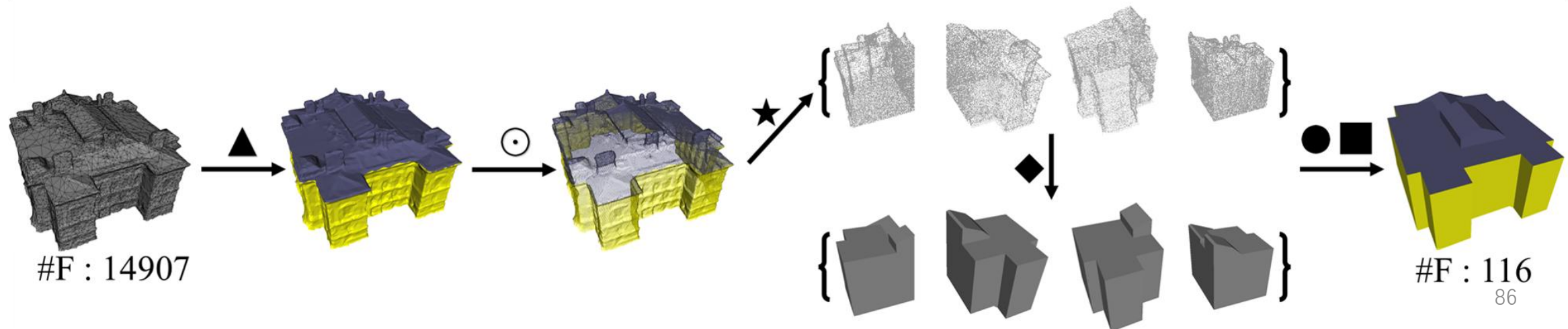
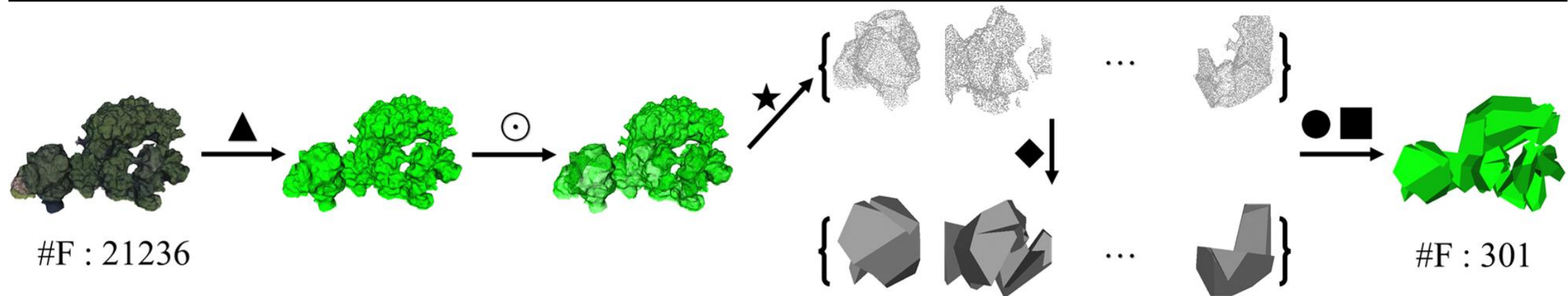
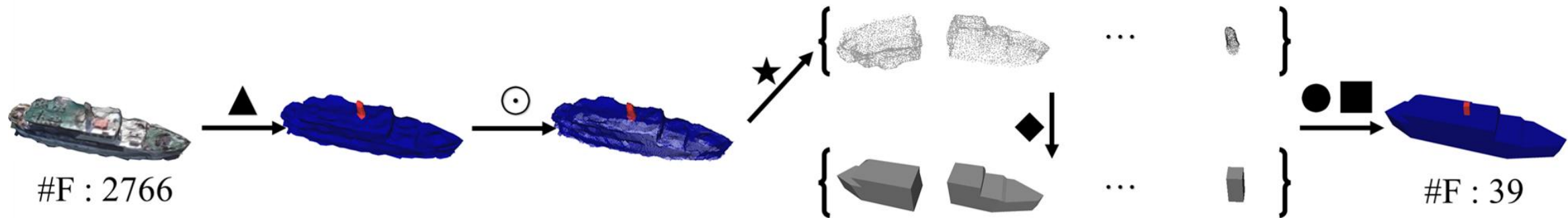
Space Partition and Surface Extraction

How to represent a semantic 3D city model with simple geometry?

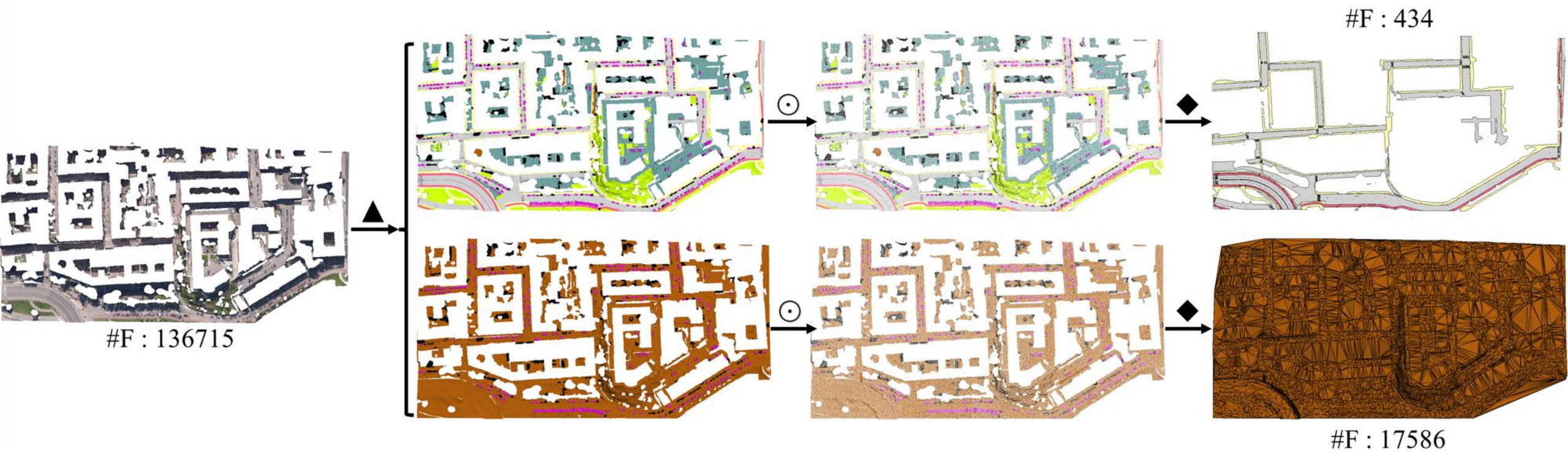


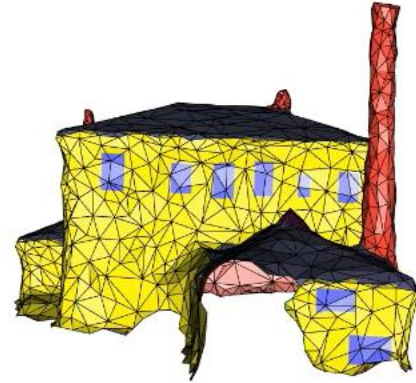
Watertightness, 2-Manifold, Computational Efficiency

How to represent a semantic 3D city model with simple geometry?

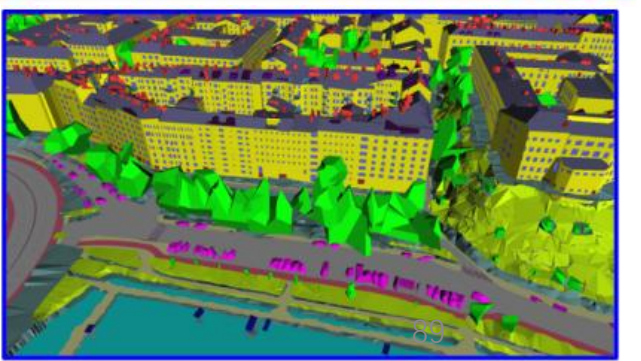
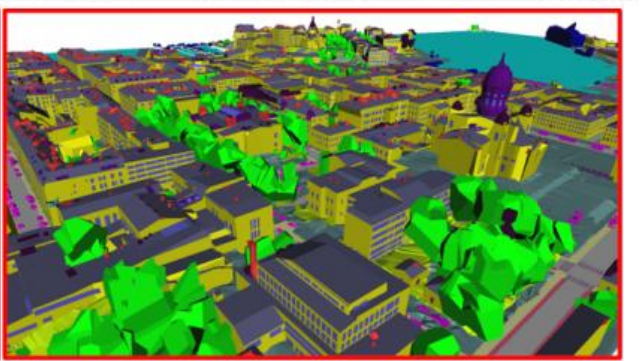
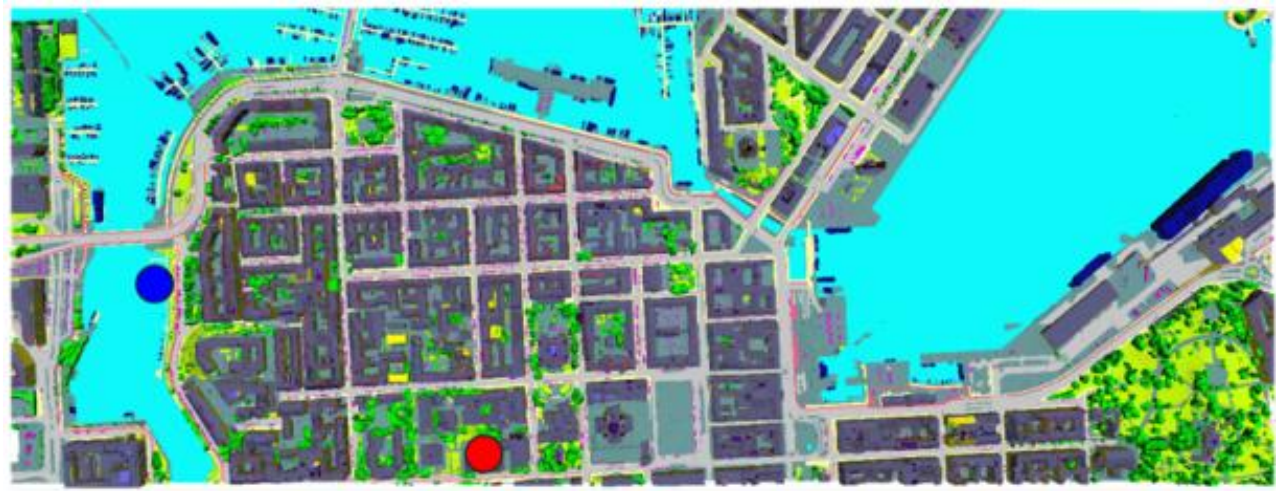
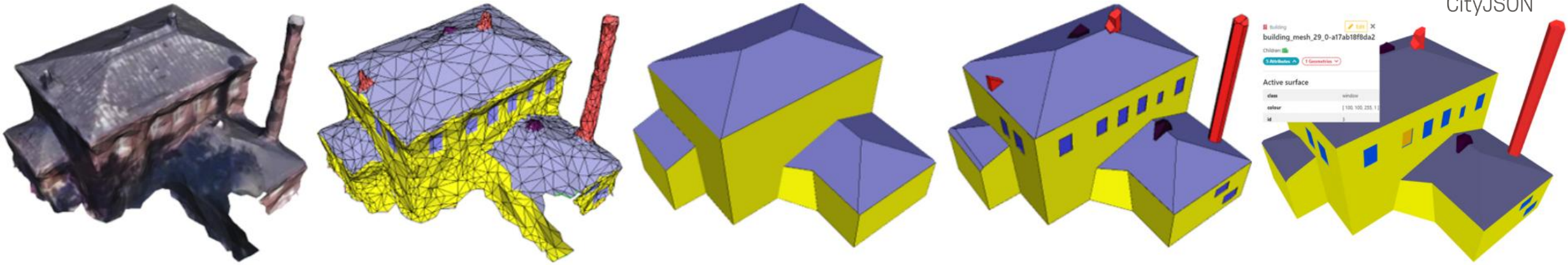


How to represent a semantic 3D city model with simple geometry?

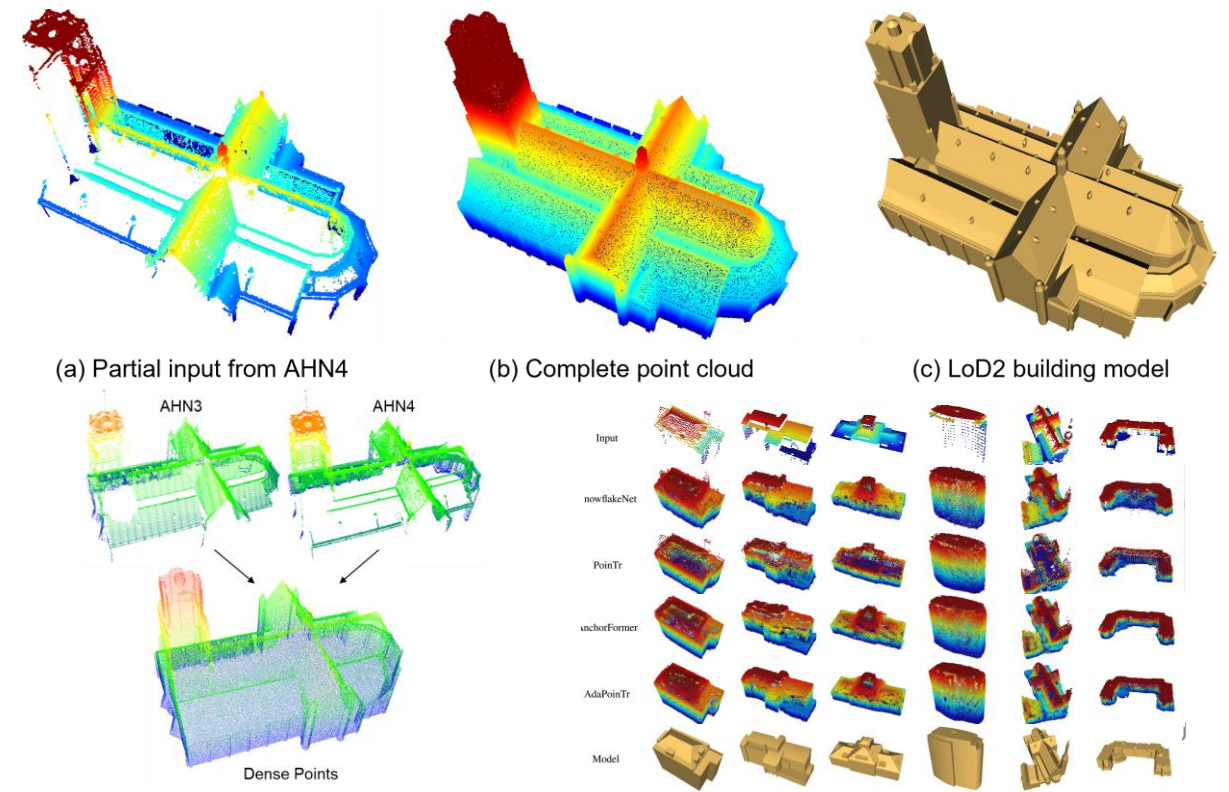
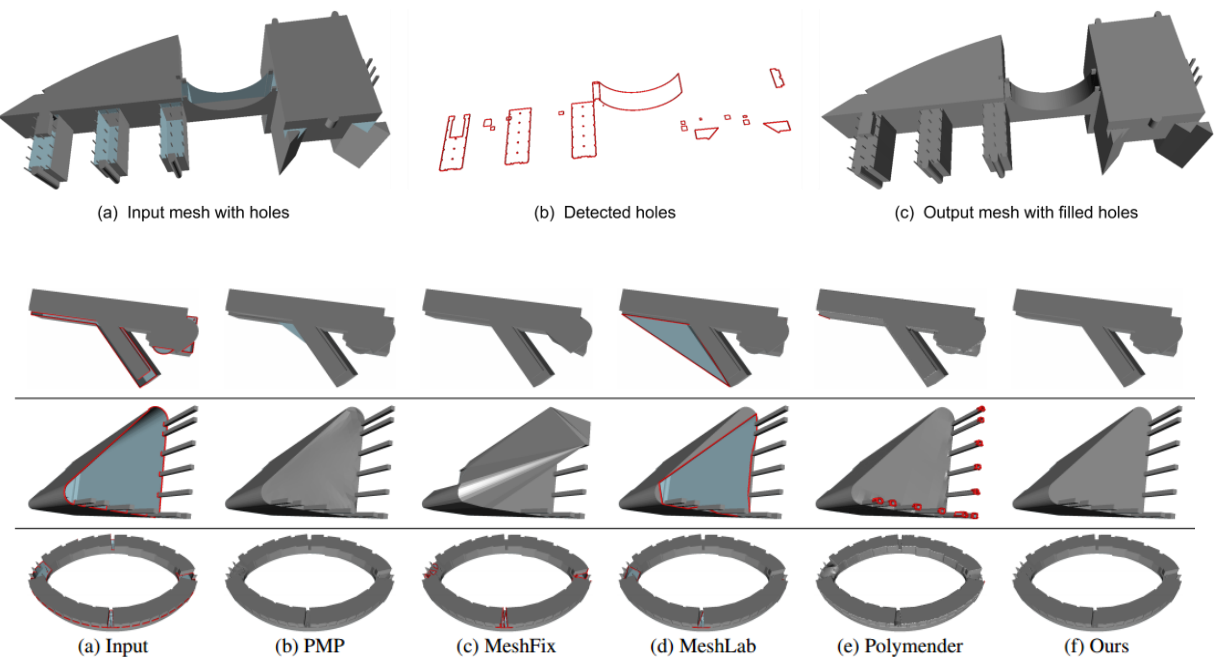
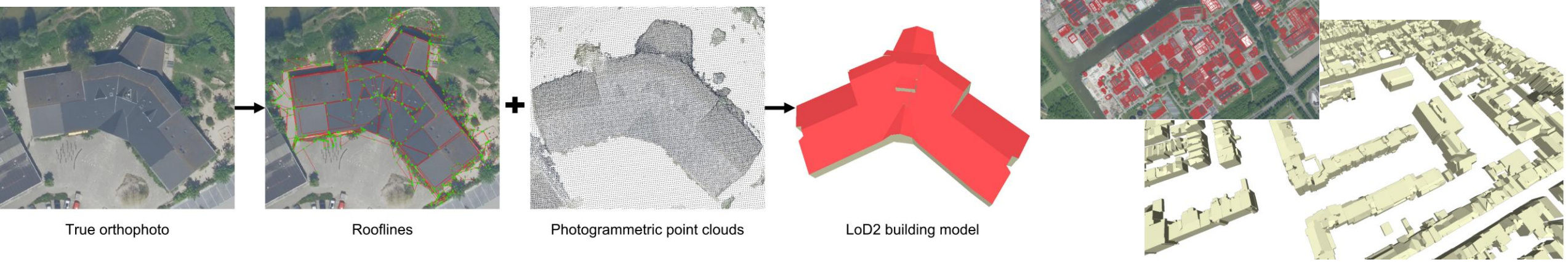




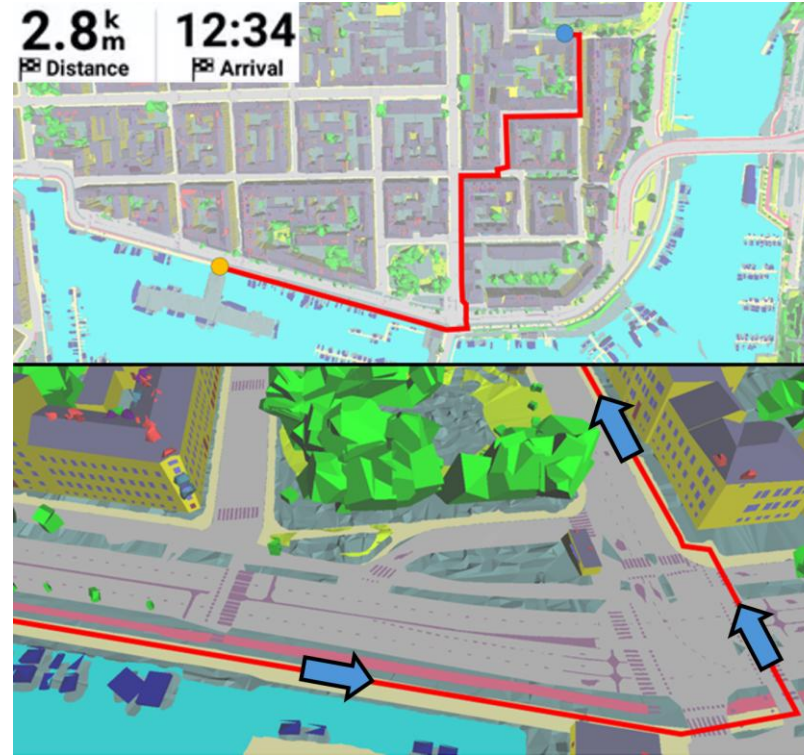
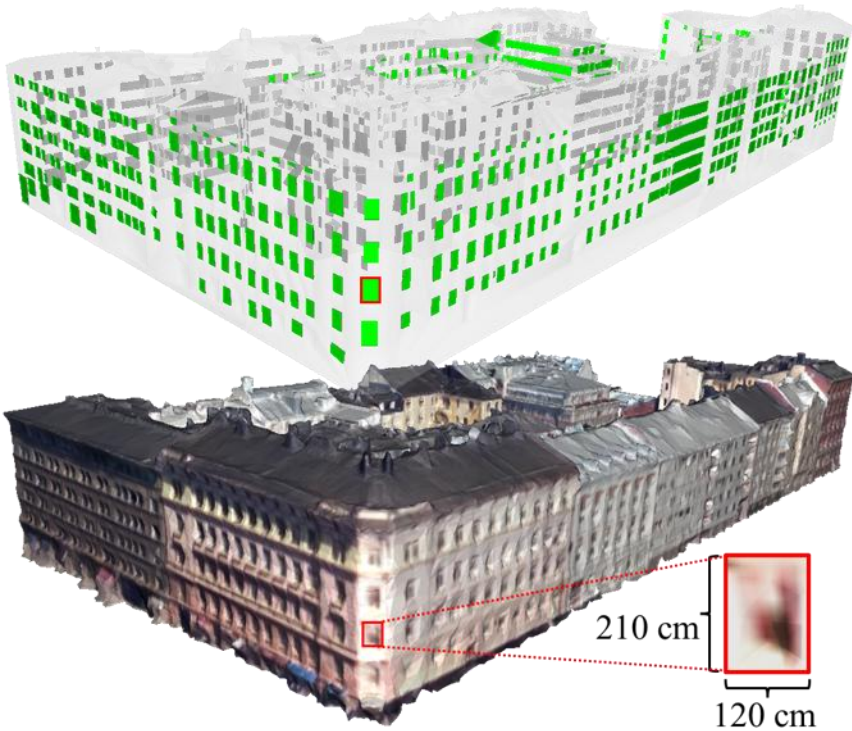
Urban Modelling (3D City Modelling)



Other research works

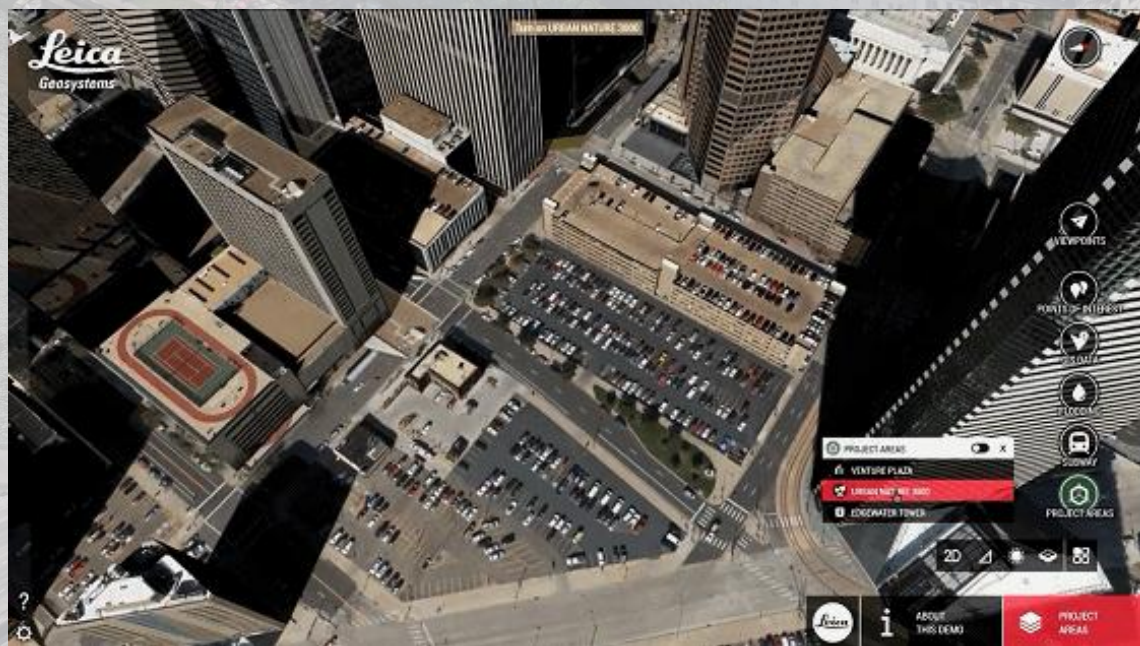
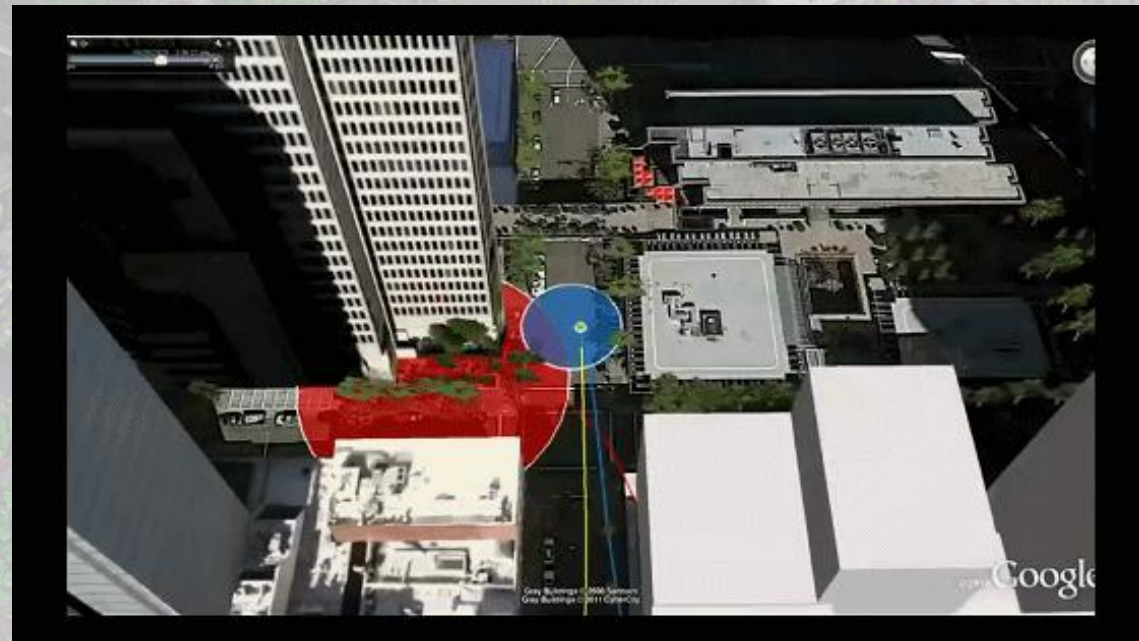


How to use these semantic 3D city models?

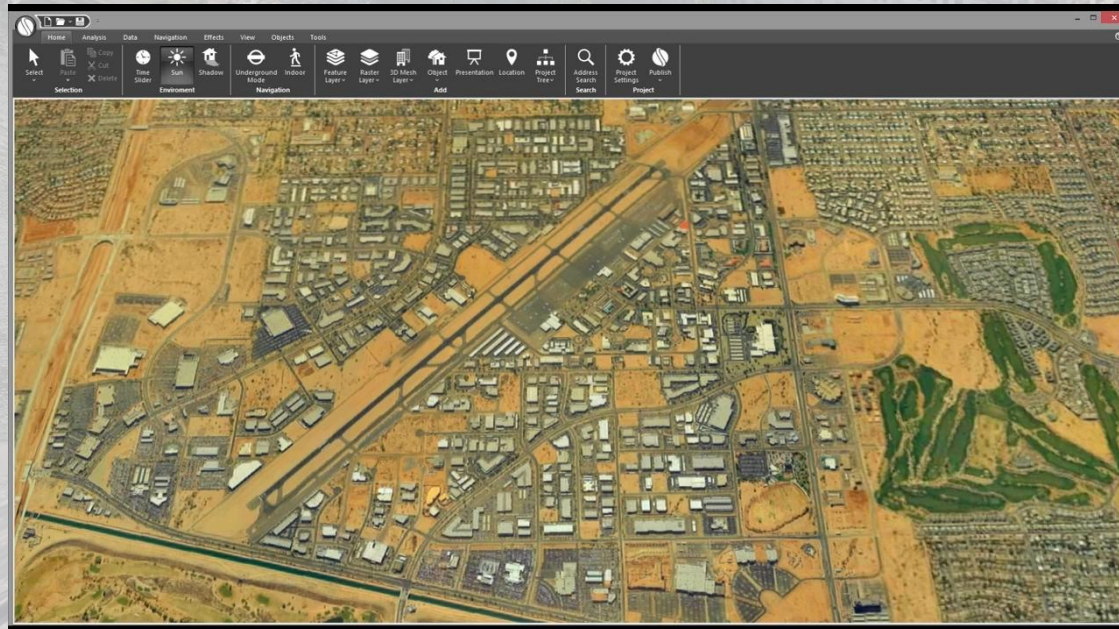
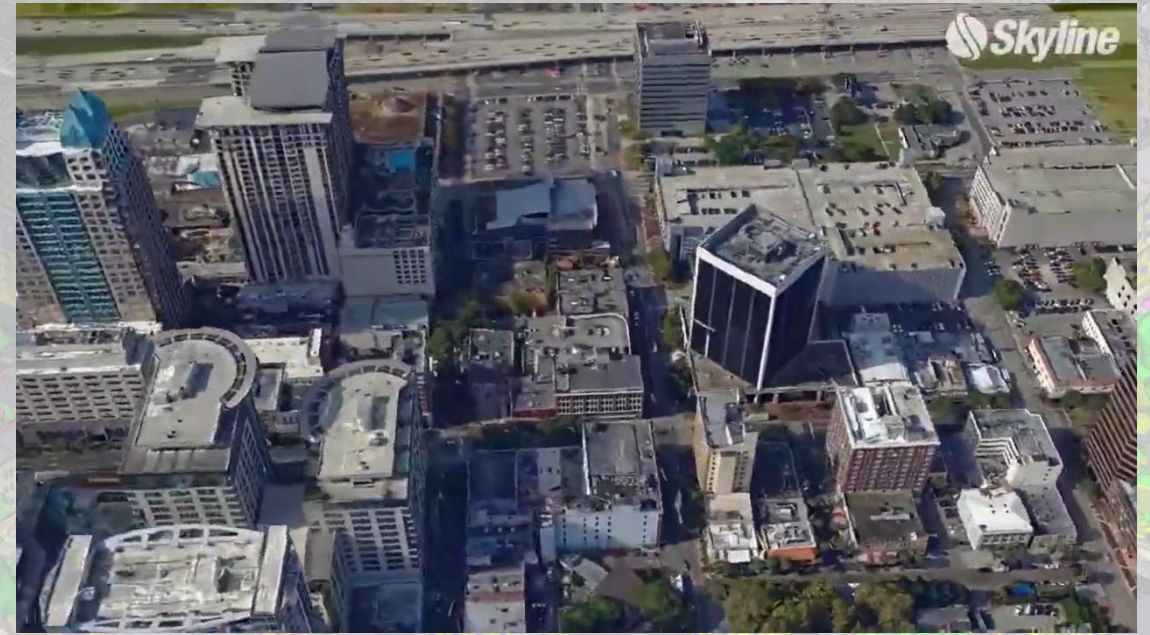


- Automatic geometric measurements
- Interactive spatial computations.
- Spatial analysis based on external data.
- Environment simulation based on physical engines.

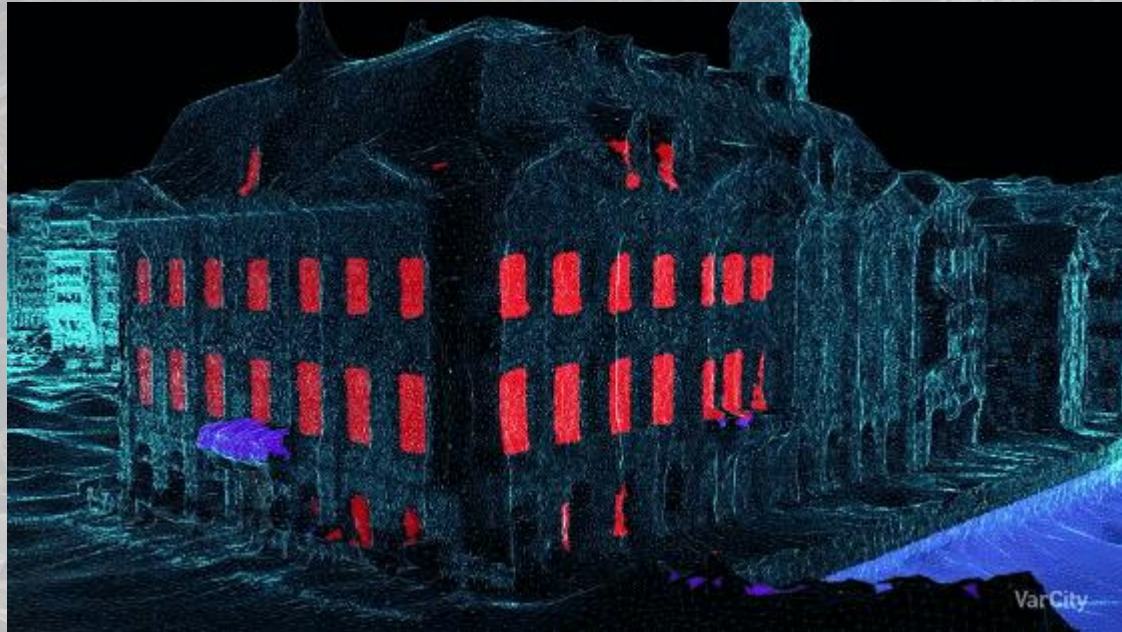
Applications **without** Semantics



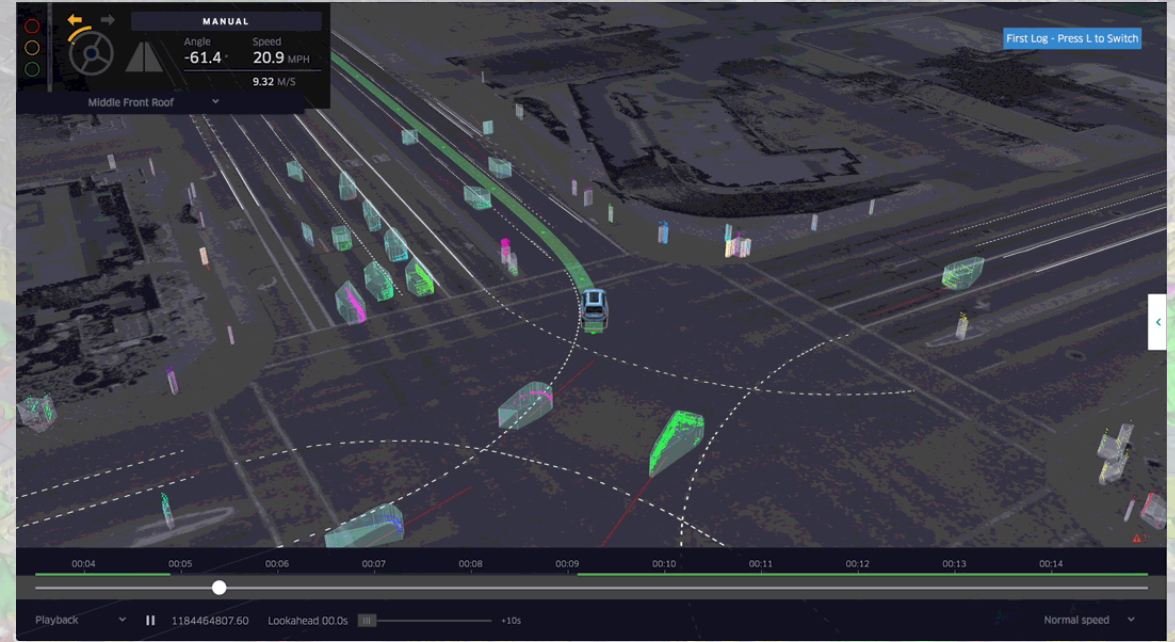
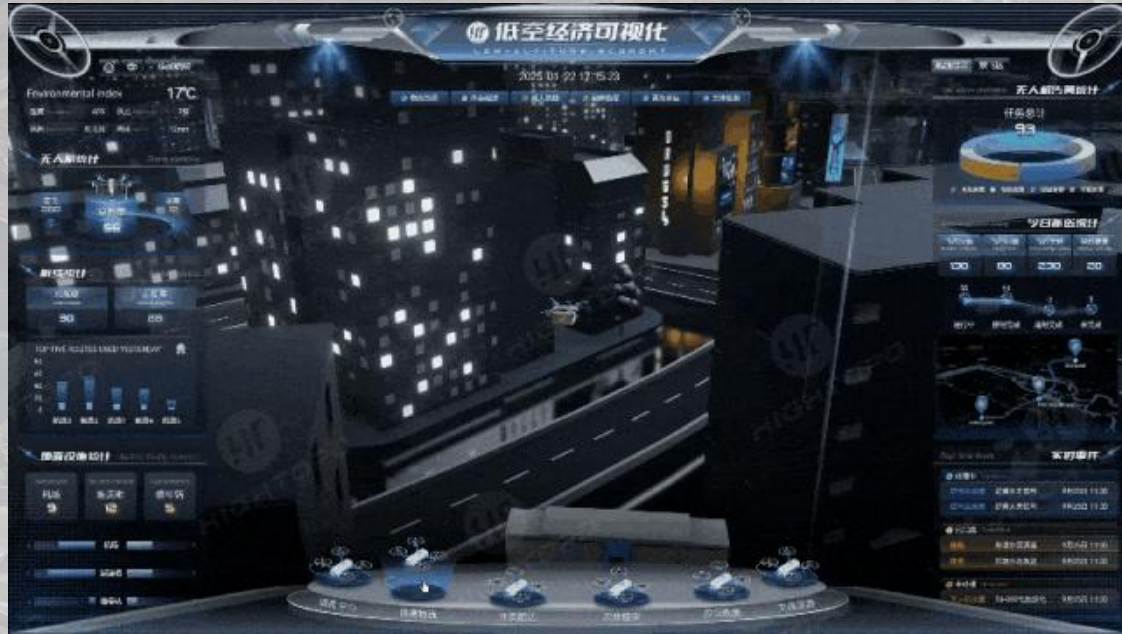
Applications **with** Semantics



Applications with Semantics



Applications in Different Fields



An aerial photograph of a city, likely New York City, showing a dense urban grid. A large, multi-story building complex in the center-right is highlighted in a bright yellow color. This complex is surrounded by several green, semi-transparent tree models. The surrounding city buildings are in a faded, greyish tone. In the foreground, a curved road and a body of water are visible. The text "6. Future Research Prospects" is overlaid in the center of the image.

6. Future Research Prospects

Future Research Prospects - Environment dynamics

- Nature's Impact on the Urban Landscape: Capturing how natural forces—extreme winds, heavy rain, intense heatwaves—dynamically interact with the 3D city.



Future Research Prospects - Carbon-based organism interactions

- The Pulse of Human and Biological Activities: Analyzing the mutual influence between human crowds, animals, and the urban environment.



Future Research Prospects - Silicon-based organism interactions

- AI Agents Navigating the Physical World: Enabling AI agents use 3D city maps to navigate urban canyons, comply with noise rules, and interact with structures.



Future Research Prospects - Cross-agent synergy

- Ultimate Collaboration: Supporting complex, real-time teamwork between human decision-makers, citizens, and AI robots within a dynamically changing digital twin.



An aerial, isometric-style rendering of a city. A large, multi-story building complex in the center-right is highlighted in a bright yellow color. The surrounding city buildings are in a muted, greyish-brown tone. The highlighted building has a complex, interconnected layout with several courtyards and courtyards containing green trees. A road with a rainbow-colored curb runs along the bottom of the highlighted building. A body of water is visible in the bottom left, and a parking lot with many cars is visible in the bottom right. The text "7. References" is overlaid in the center of the image.

7. References

Open-Source Projects: Source code and datasets



3D_Urban_Mesh_Annotator Public

114 Commits

Urban Mesh Annotation Tool

Mesh annotation tool for labelling urban scenes. Before you import your model, please check your input mesh is in ascii ".ply" format. Note that non-manifold meshes are not supported in this tool. If you still want to use it, please use MeshLab to repair it first. For more information, please visit our project website.

CGAL	Clean the master for first release	4 years ago
data	Add new test data remove verbose warnings.	4 years ago
docs	Add manual + data to repo	4 years ago
pics	Update README	3 years ago
src	Fixed bugs of segment area slider.	3 years ago
gignore	suppress Qt deprecated warnings	4 years ago
LICENSE	Initial commit.	4 years ago
README.md	Merge branch 'backup'	3 years ago
Tutorial.md	Update tutorial	3 years ago

Roofline-extraction-from-orthophotos Public

6 Commits

Unsupervised Roofline Extraction from True Orthophotos

This is the implementation part of the paper: [Unsupervised Roofline Extraction from True Orthophotos](#). First, we use a true orthophoto as input. Next, we perform line extraction to partition the building footprint, which generates separate roof parts. We then utilize a dense point cloud to extrude the partition results and create a LoD2 building model. For generating LoD2 building models, please refer to the repository [gifu-building-reconstruction](#).

Building-PCC-Building-Point-Cloud-Completion-Benchmarks Public

8 Commits

Building-PCC-Building-Point-Cloud-Completion-Benchmarks

This is the implementation of the Building-PCC paper: [Building-PCC: Building Point Cloud Completion Benchmarks](#). This repository contains scripts for generating Building-PCC data, links for data downloads, test codes for state-of-the-art methods, pre-trained models, and evaluation results.

PSSNet Public

37 Commits

PSSNet: Planarity-sensible Semantic Segmentation of Large-scale Urban Meshes

This is the implementation of the paper: [PSSNet: Planarity-sensible Semantic Segmentation of Large-scale Urban Meshes](#). Specifically, it consists of two steps: Step-1: planarity-sensible over-segmentation; Step-2: semantic classification.

SUMS-Semantic-Urban-Mesh-Segmentation-public Public

5 Commits

SUMS: Semantic Urban Mesh Segmentation.

SUMS is the official implementation of the paper: [SUM: A Benchmark Dataset of Semantic Urban Meshes](#). Specifically, it is an open-source program for automatic semantic segmentation of large-scale urban texture meshes. It is mainly implemented in C++ and other open-source libraries, such as [CGAL](#) and [Easy3D](#). For more information, please visit our [project website](#).

Automatic-Repair-of-LoD2-Building-Models Public

5 Commits

Automatic Repair of LoD2 Building Models

This repository provides the implementation for the automatic repair of LoD2 building models. It is primarily developed using C++ and leverages open-source libraries such as [CGAL](#) and [Easy3D](#). Our paper, [Filling holes in LoD2 building models](#), has been accepted for presentation at the 3D Geoinfo 2024 conference. We are currently releasing the source code of our code, which focuses on mesh hole filling, along with

References

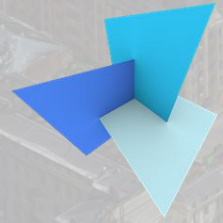
- 1). **Gao, W.**, Nan, L., and Ledoux, H. (2026). 3DPolyWorld: Bridging 3D Data to Compact 3D Models (Under preparation for submission to *Nature Computational Science*).
- 2). **Gao, W.**, Peters, R., Ledoux, H., and Stoter, J. (2026). Automatic Repair of 3D Building Models. (Under preparation for submission to *ISPRS P&RS*).
- 3). Balado, J., Feng ,Y., Qiu, Z., **Gao, W.**, Julin A., Real-world 3D Spaces in Extended Reality Applications: A Systematic Review. (Major revision, submitted to *The Photogrammetric Record*)
- 4). A. Rahmawati, **Gao, W.**, Agugiaro G., León-Sánchez C. (2026). Scenario-based energy simulation of tree planting strategies to reduce the heating and cooling demand of buildings under 2050 climate conditions (Accepted by *ISPRS Congress 2026*).
- 5). Mantas D., **Gao, W.**, Ledoux, H. (2025). RoofSense: A Multimodal Semantic Segmentation Dataset for Roofing Material Classification. In: *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences X-4/W6-2025*, pp. 153–160.
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- 7). Ceccarelli G., **Gao, W.**, Peters R.(2025). Semantic segmentation of point clouds with the 3D medial axis transform. In: *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences X-4/W6-2025*, pp. 33–40.
- 8). **Gao, W.**, Agugiaro G., León-Sánchez C.(2025). Data-Driven Energy Simulations To Evaluate Positive Energy District Potential In Rotterdam. In: *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences X-4/W7-2025*, pp. 25–32.
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- 10). **Gao, W.** (2024c). Semantic understanding of urban scenes from textured meshes. Doctor Dissertation (TU Delft). *Delft University of Technology*.
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- 12). **Gao, W.**, Peters, R., Ledoux, H., and Stoter, J. (2024a). Filling holes in LoD2 building models. In: *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences X-4/W5-2024*, pp. 171–177.
- 13). **Gao, W.**, Peters, R., and Stoter, J. (2024c). Unsupervised Roofline Extraction from True Orthophotos for LoD2 Building Model Reconstruction. In: *Recent Advances in 3D Geoinformation Science*. Springer Nature Switzerland, pp. 425–436
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- 15). **Gao, W.**, Nan, L., Boom, B., and Ledoux, H. (2021). SUM: A benchmark dataset of Semantic Urban Meshes. In: *ISPRS Journal of Photogrammetry and Remote Sensing* 179, pp. 108–120.
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Thank you for your attention!



