From Points to Prints

Generating Building Roofprints and Footprints from Airborne Lidar Data and Inaccurate Outlines

A4 Presentation

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Context

Roofprint vs. footprint

	Roofprint	**Footprint**
Defined by	Roof	Façades
Comes from	Aerial data (images, ALS)	Terrain measurements (TLS, MLS)
Used for	3D modelling, solar potential	Tax estimation, energy consumption

Table 1: Comparison between roofprints and footprints

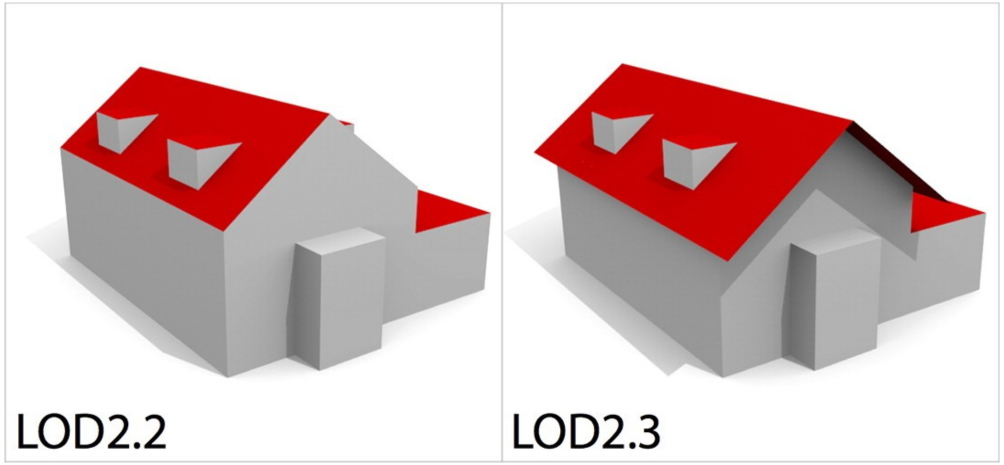


Figure 1: Part of the visual definition of buildings Level of Detail (LoD) containg LoD 2.2 and 2.3 (Biljecki et al., 2016).

Strengths and weaknesses of BD TOPO

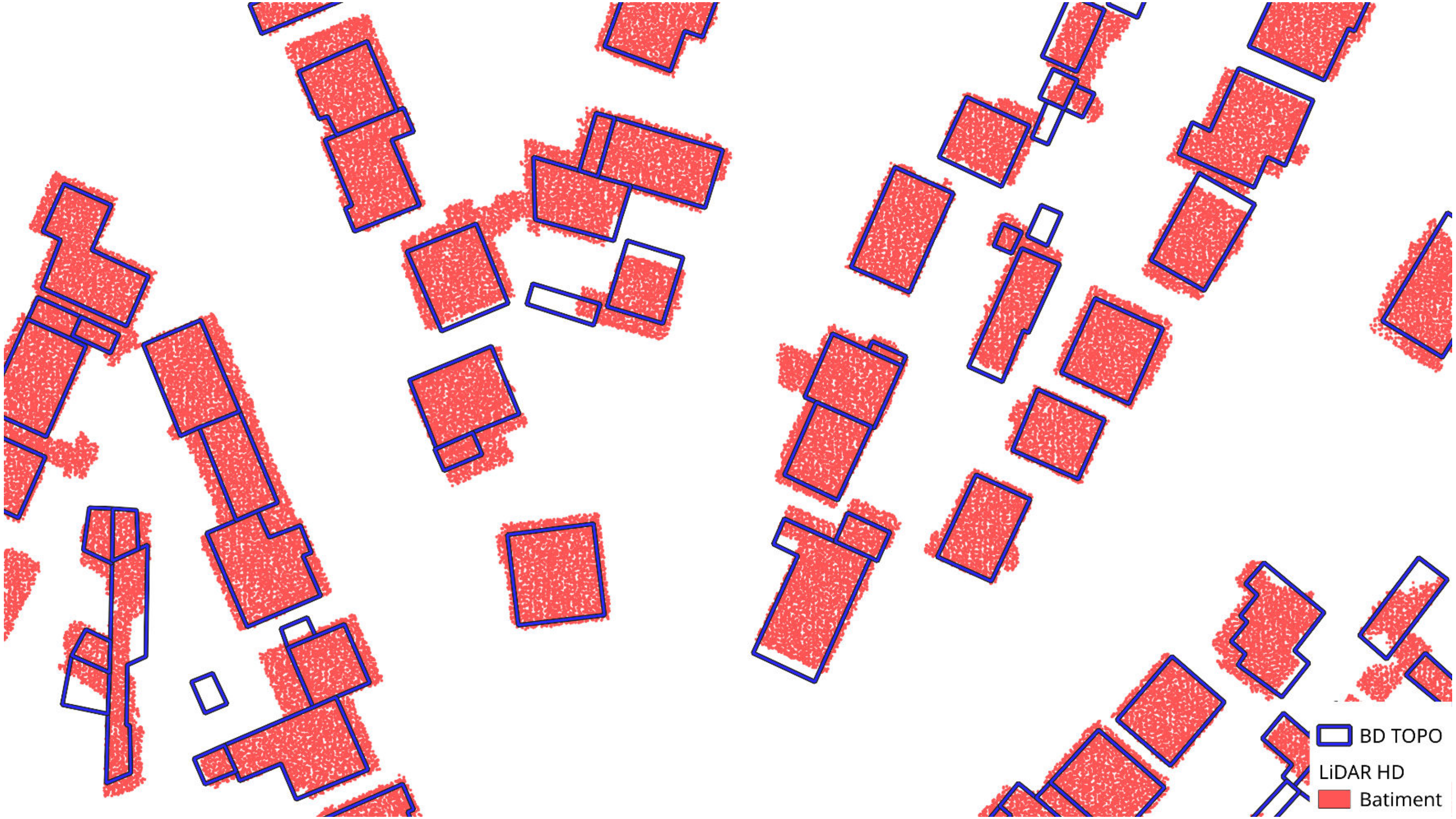


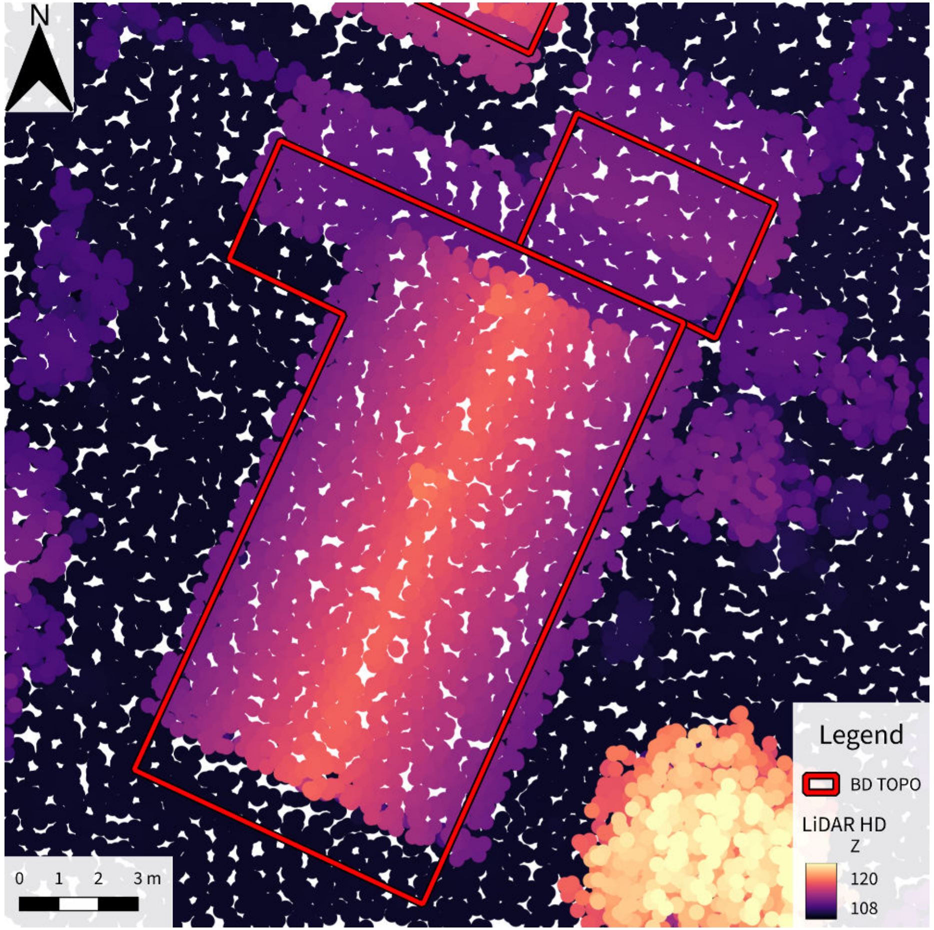
Figure 2: BD TOPO buildings are most of the time footprints, and often shifted.

Research questions

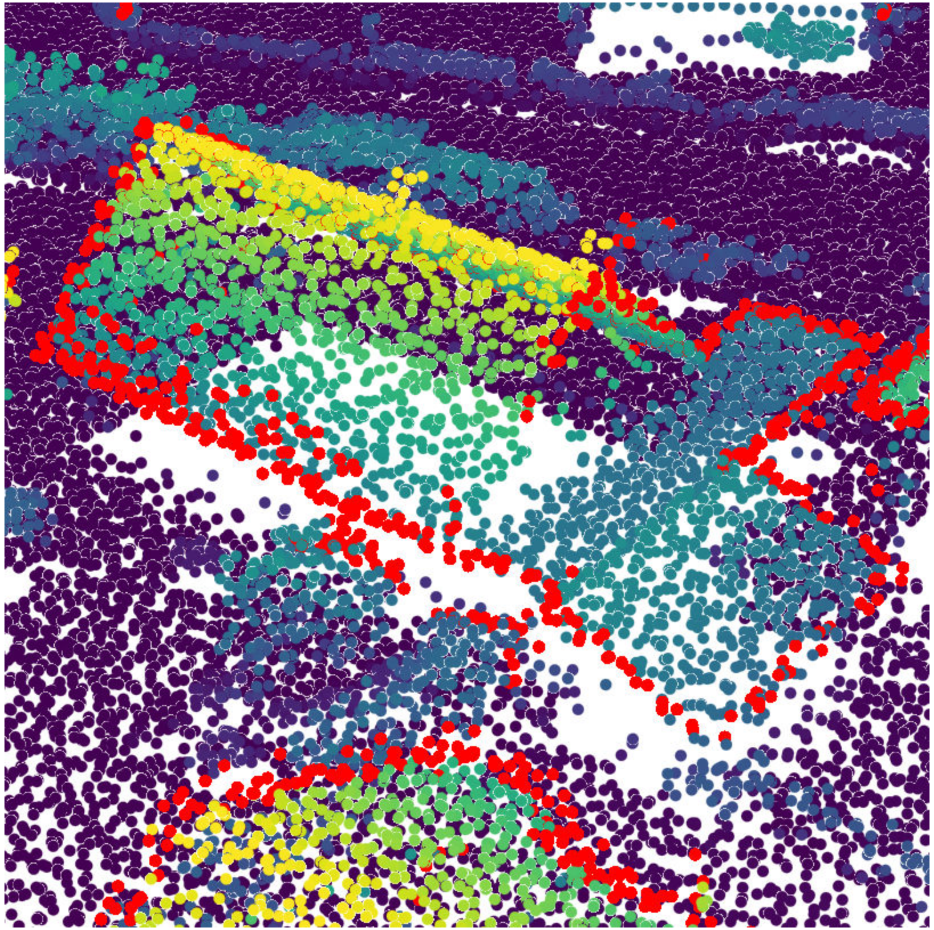
> *How to generate coherent building* ***roofprints*** *and* ***footprints*** *from high-density* ***ALS*** *point clouds and existing* ***imprecise outlines****?*

Overview of the methodology

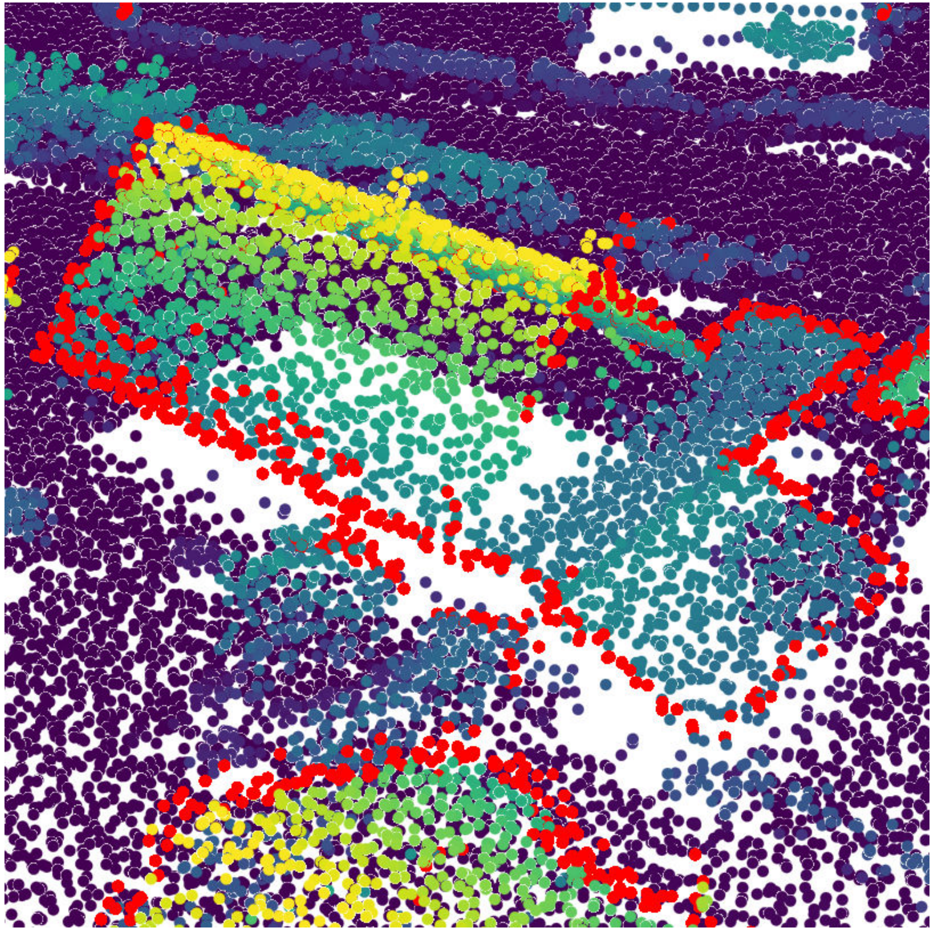
1. BD TOPO and LiDAR HD



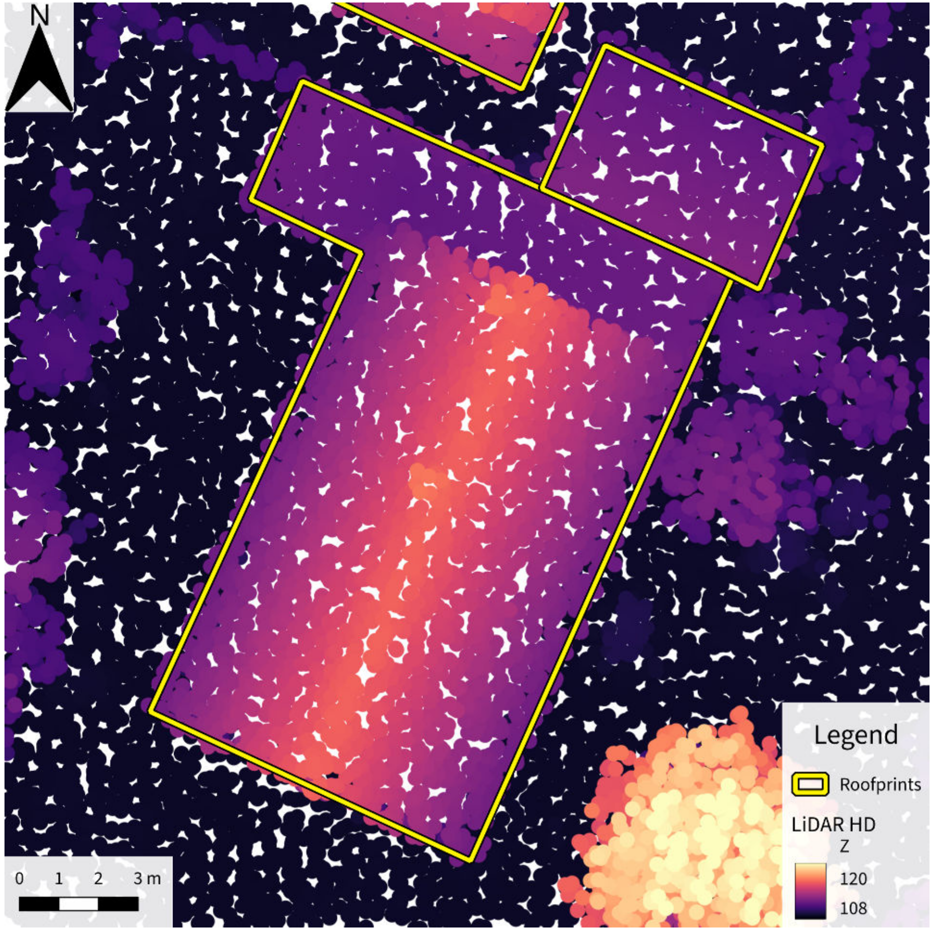
2. Find roof edge points



2. Find roof edge points

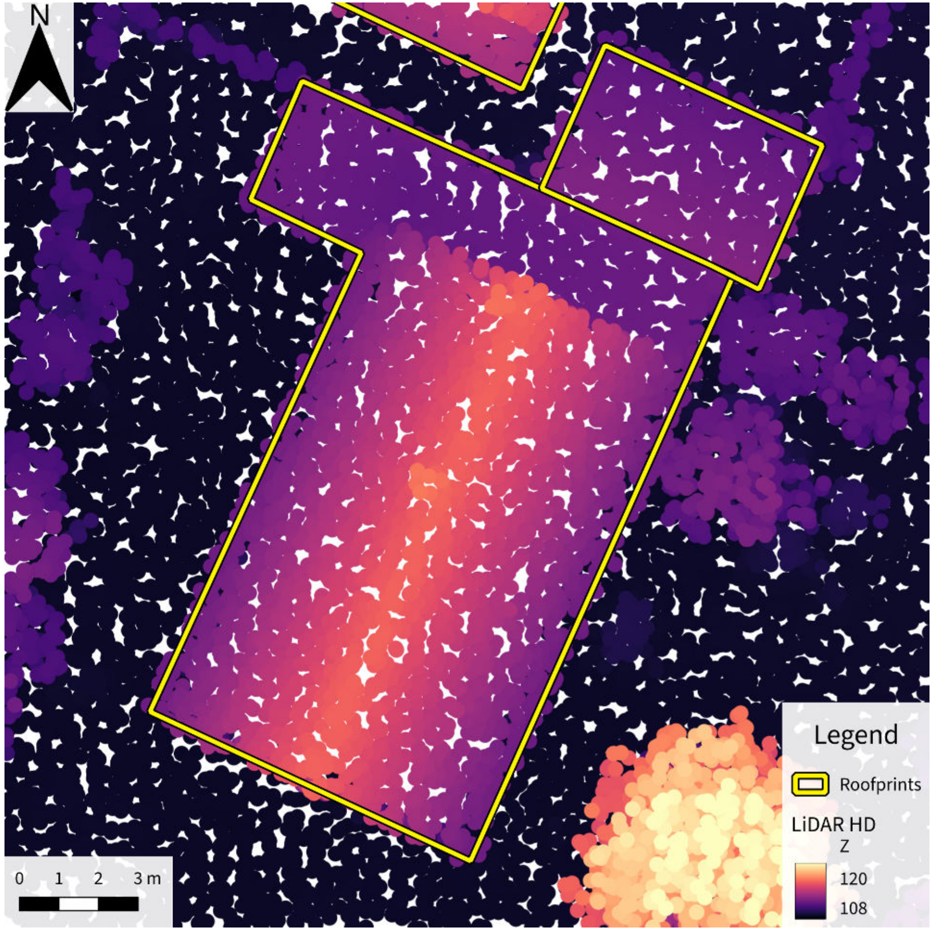


3. Align into a roofprint

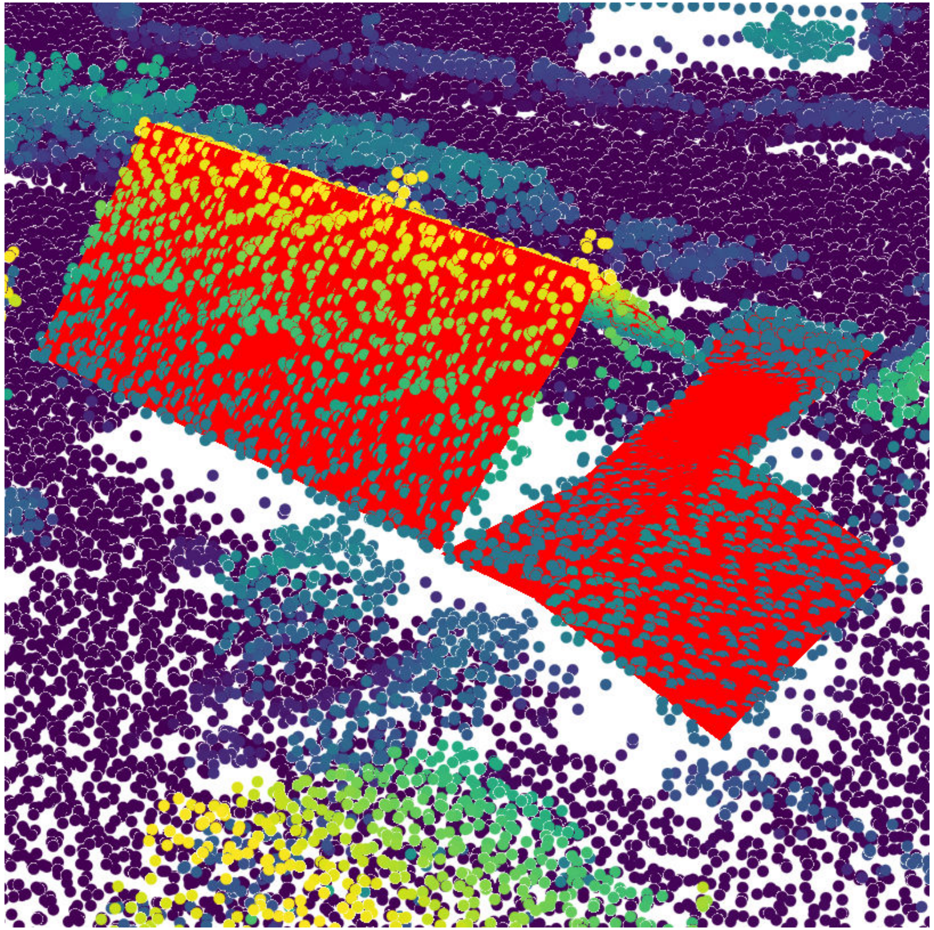


Overview of the methodology

3. Align into a roofprint

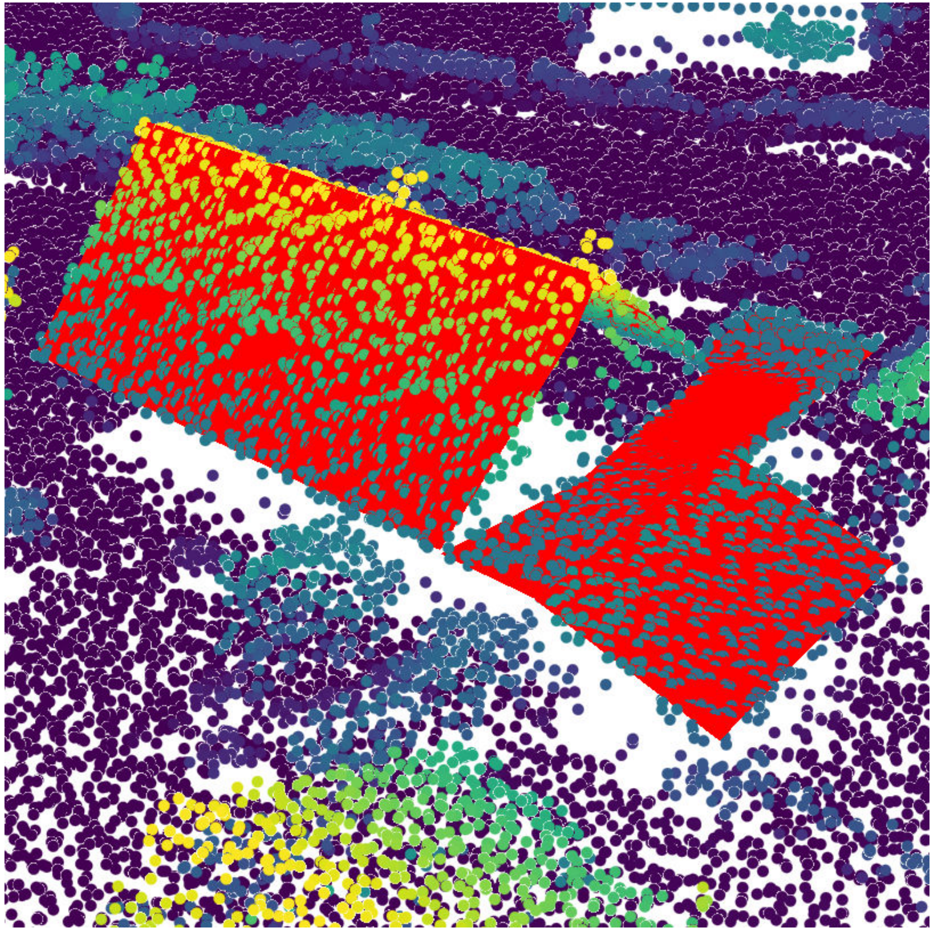


4. Generate 3D roof model

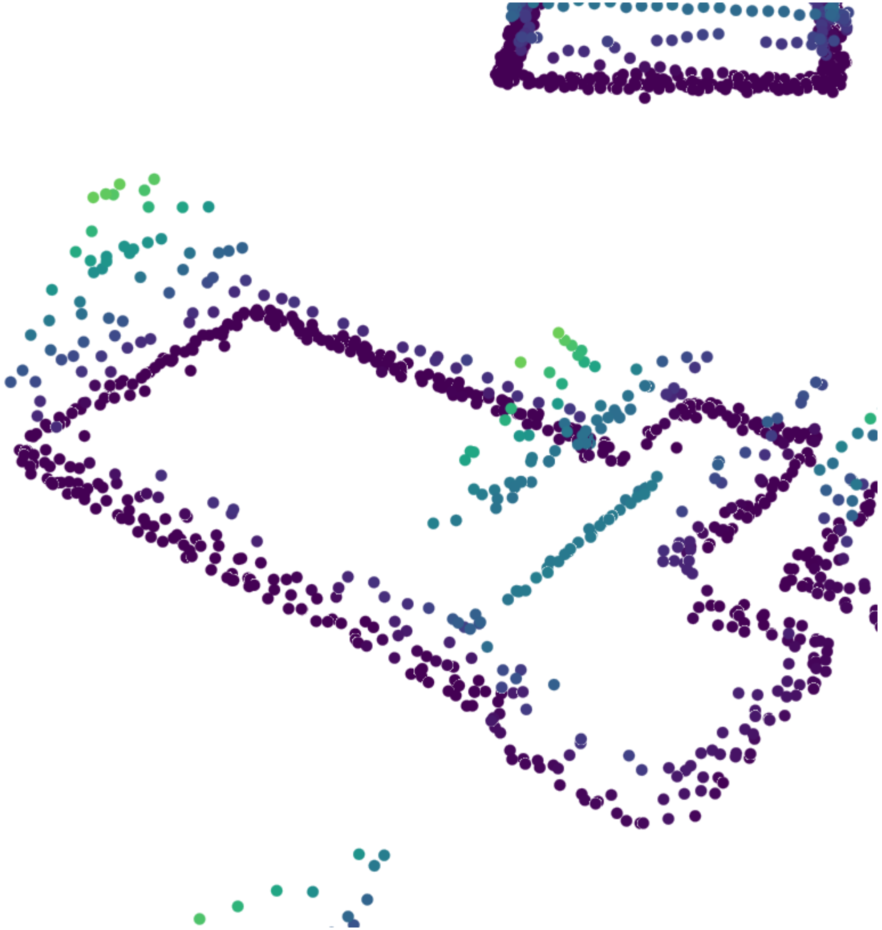


Overview of the methodology

4. Generate 3D roof model

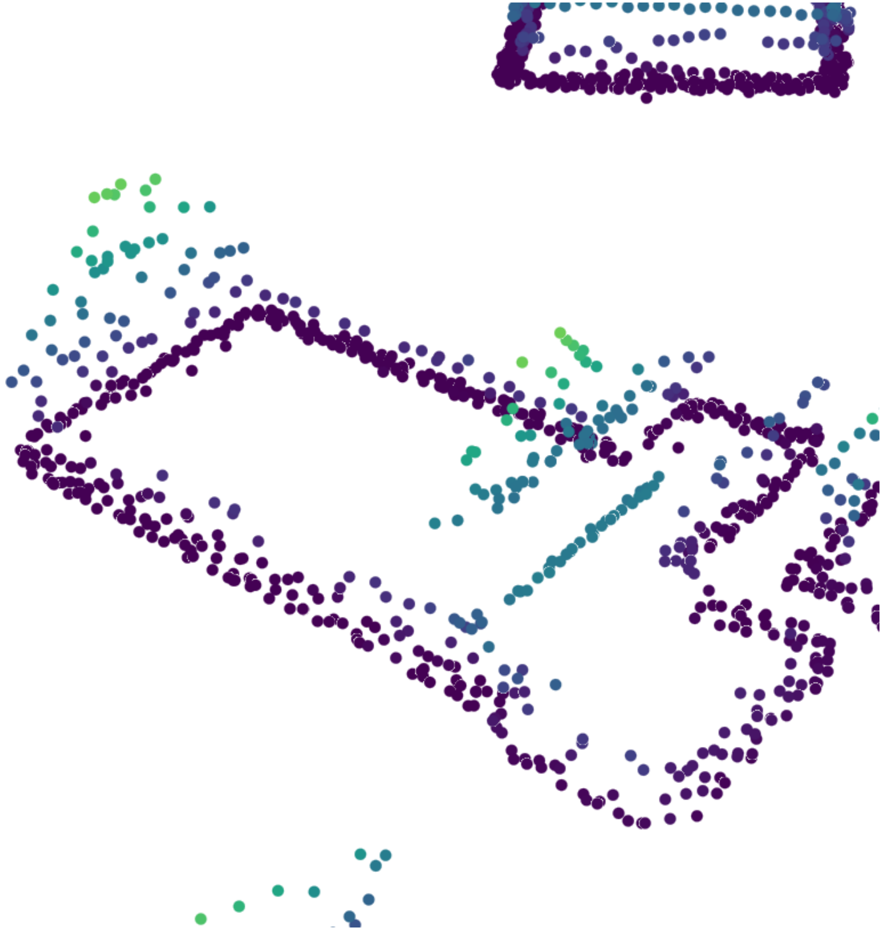


5. Find façade and ground points

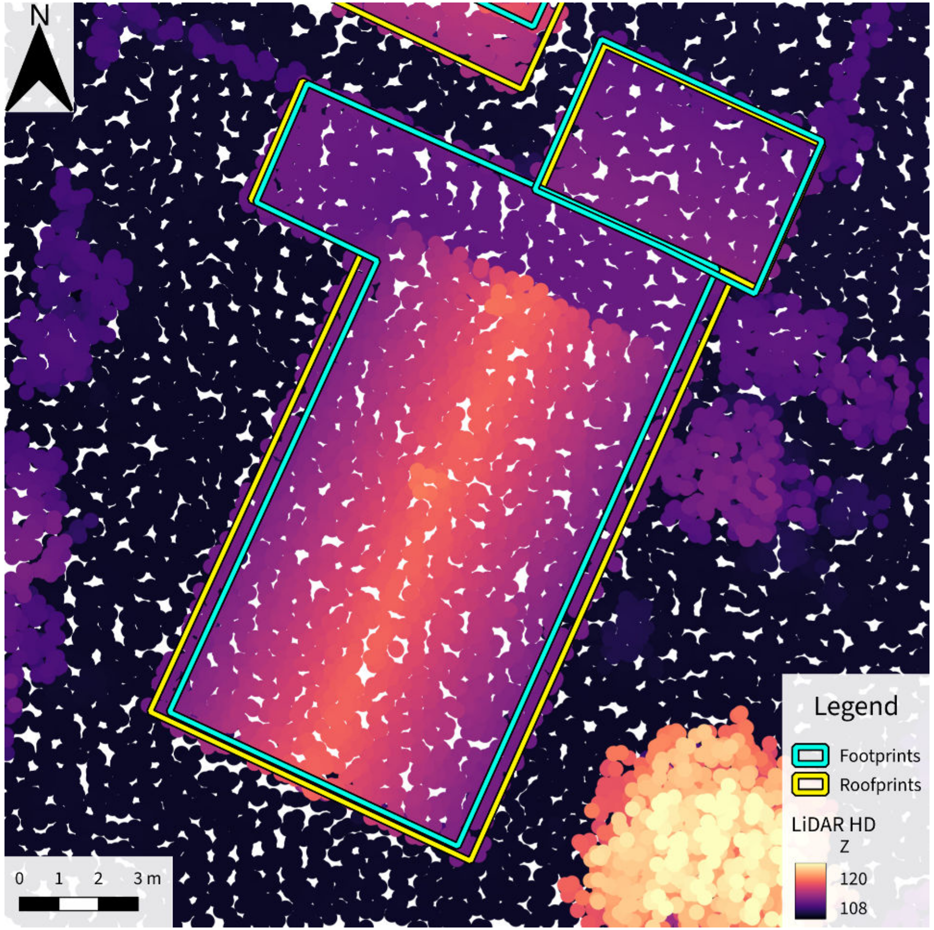


Overview of the methodology

5. Find façade and ground points

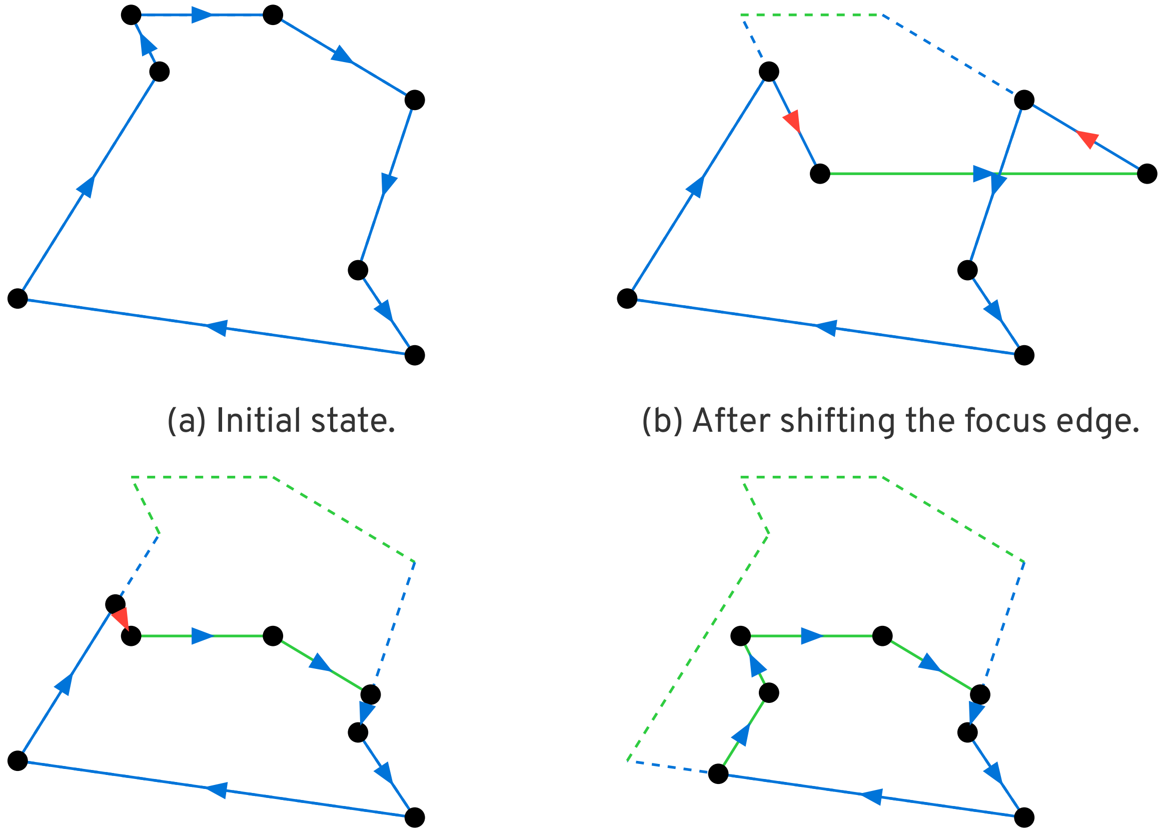


6. Align into a footprint



Polygon deformation

Our simple approach



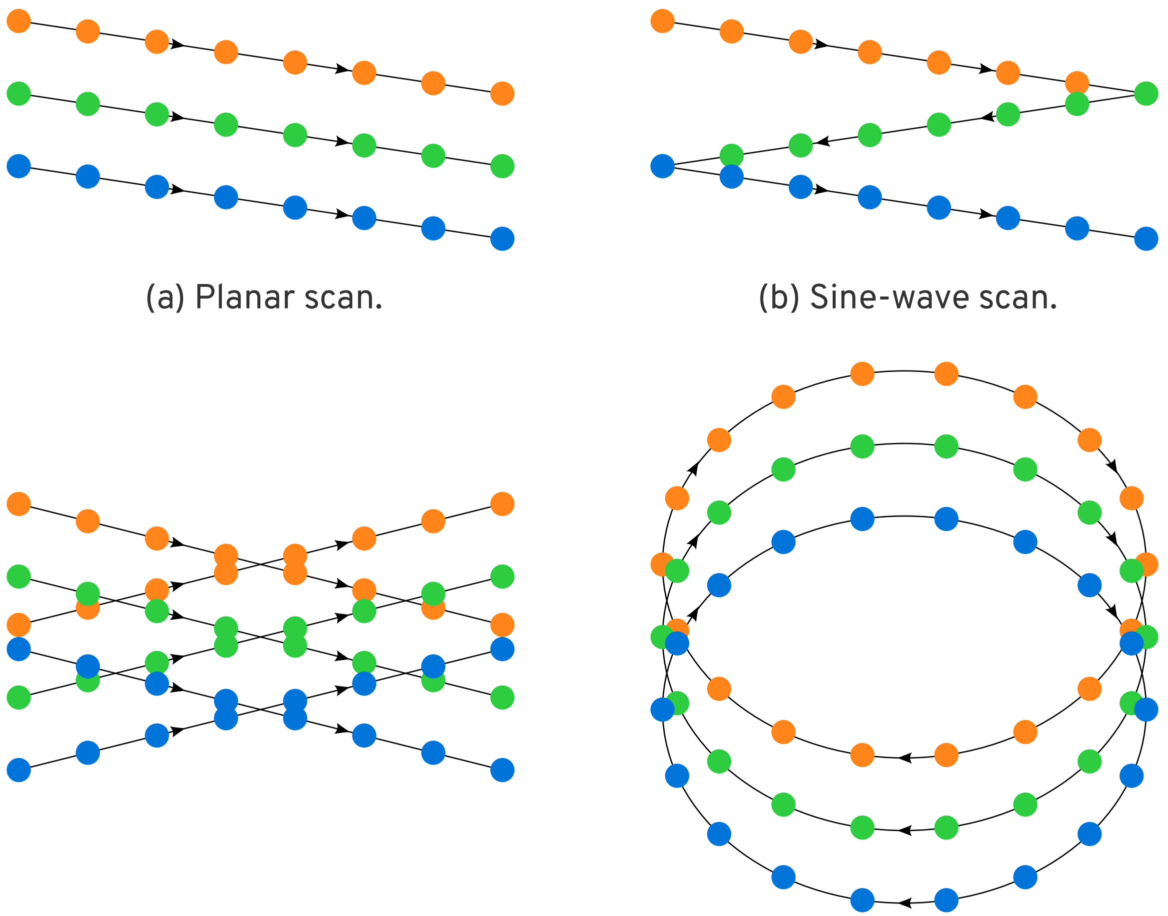
(a) Initial state. (b) After shifting the focus edge.

(c) First step of the resolution. (d) Second and final step of the resolution.

Figure 3: Illustration of the polygon deformation algorithm on a single polygon.

Roofprints

Point cloud topology



(a) Planar scan.

(b) Sine-wave scan.

(c) Cross scan.

(d) Circular scan.

Figure 4: Illustration in 2D (view from the top) of different types of ALS sensors. inspired from (Wu et al., 2026) .

Roofprints evidence

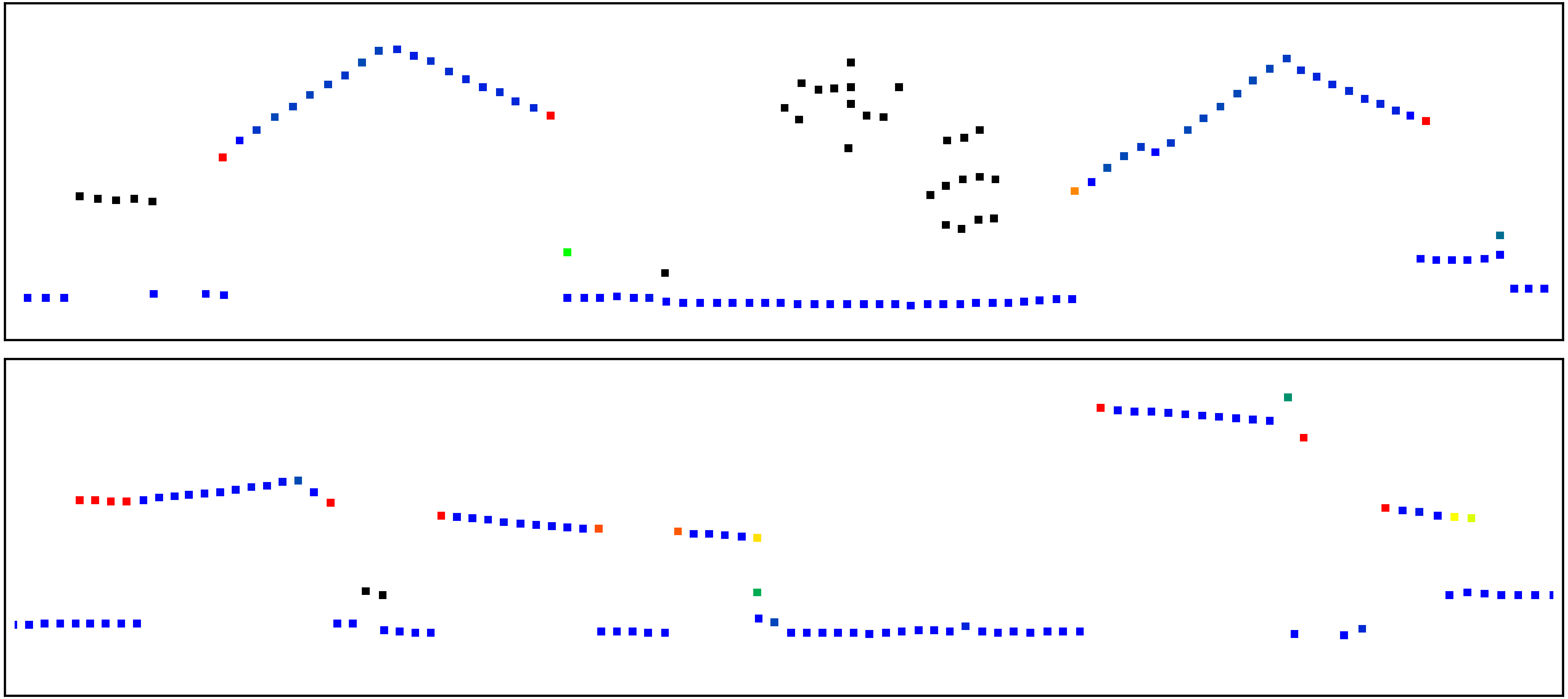


Figure 5: Two examples of the height differences obtained on a scan line. Black points are vegetation points, and for the other points the colour represents the value of Δh, with blue-green-yellow-red from low to high values.

Assign a score to roofprints

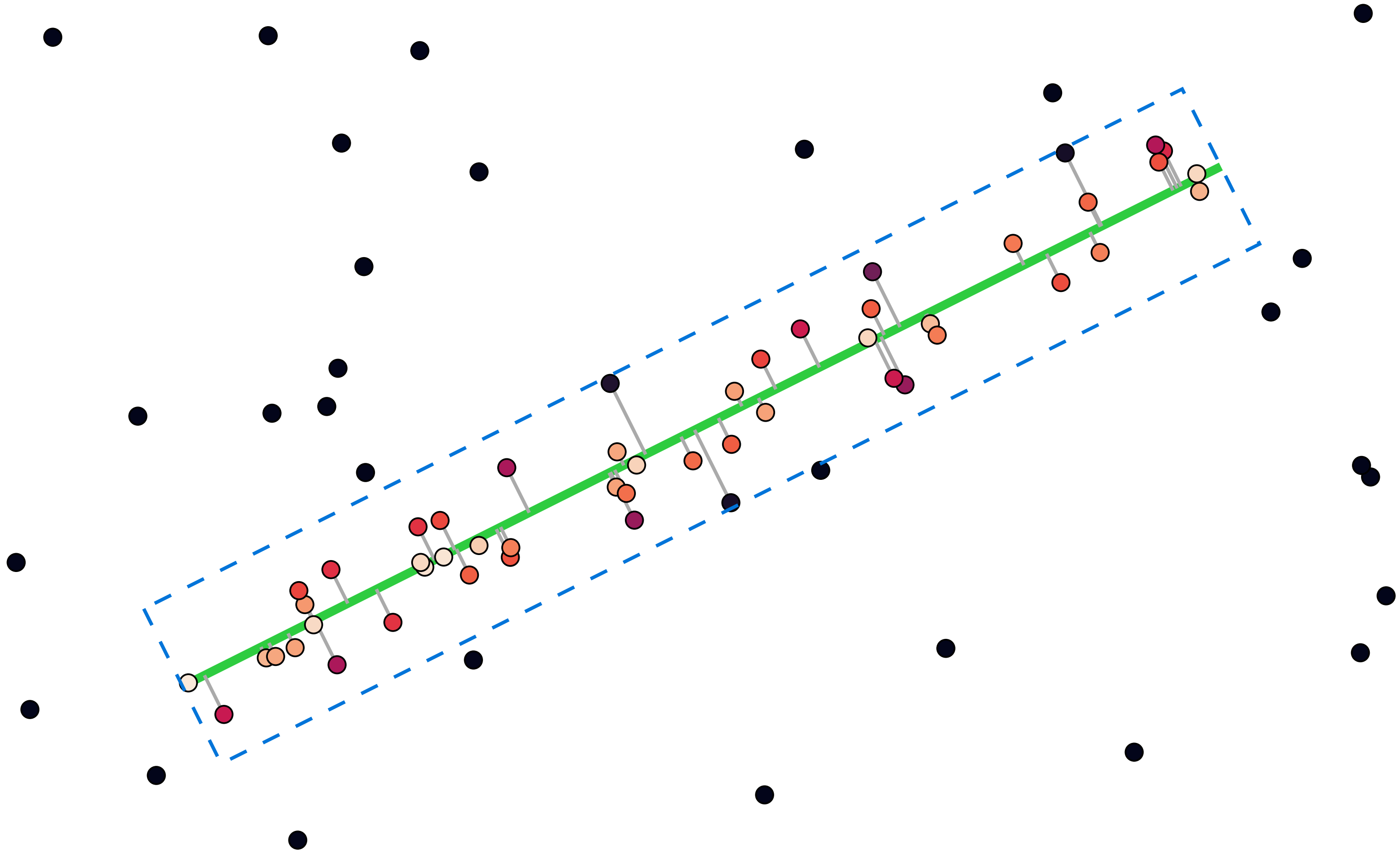
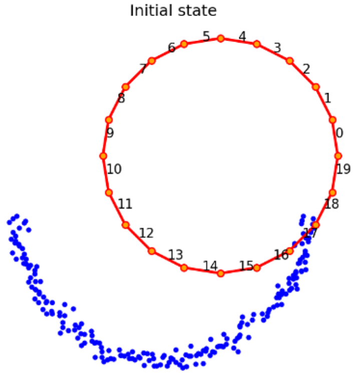
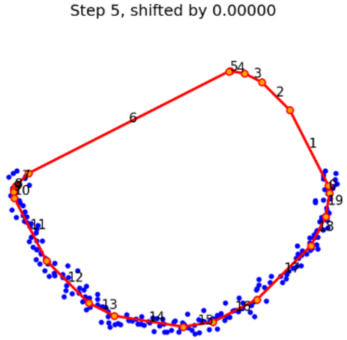


Figure 6: Illustration in 2D (view from the top) of the proximity score for an edge.

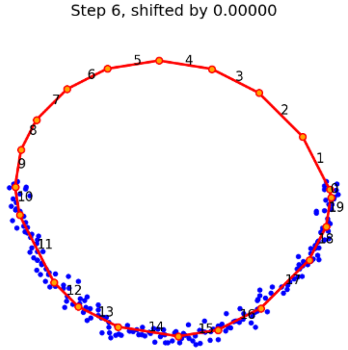
Need for regularization



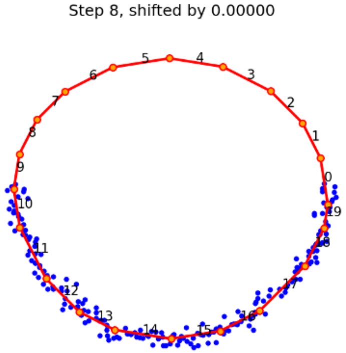
(a) Initial state



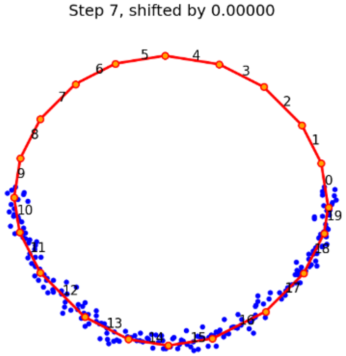
(b) $\alpha = 0.00$ (no regularisation)



(c) $\alpha = 0.05$



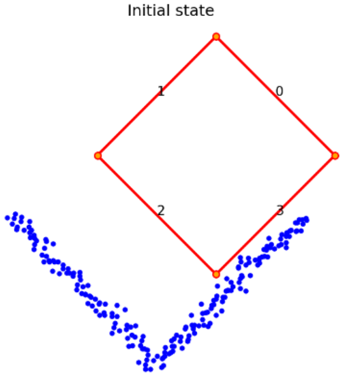
(d) $\alpha = 0.20$



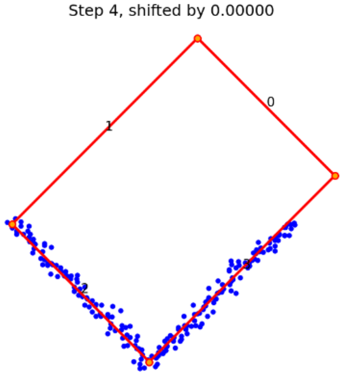
(e) $\alpha = 1.00$

Figure 7: Matching a circle to a half-circle of points with different values of the regularization parameter α.

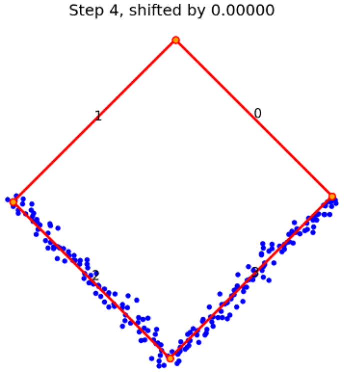
Need for regularization



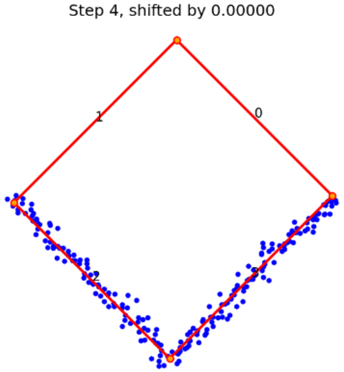
(a) Initial state



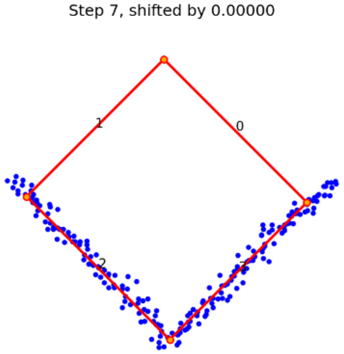
(b) $\alpha = 0.00$ (no regularization)



(c) $\alpha = 0.05$



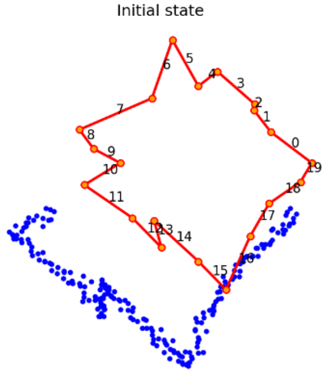
(d) $\alpha = 0.20$



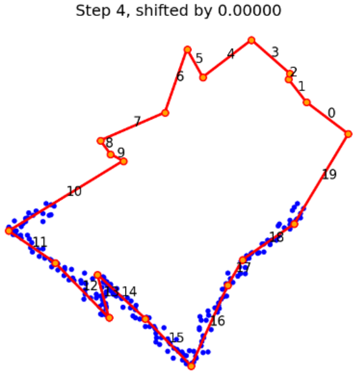
(e) $\alpha = 1.00$

Figure 8: Matching a square to points along two sides of a larger square with different values of the regularization parameter α.

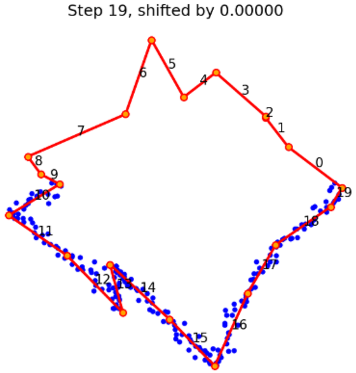
Need for regularization



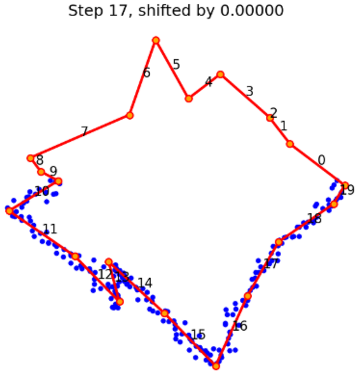
(a) Initial state



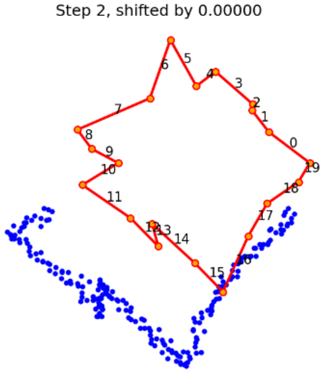
(b) $\alpha = 0.00$ (no regularization)



(c) $\alpha = 0.05$



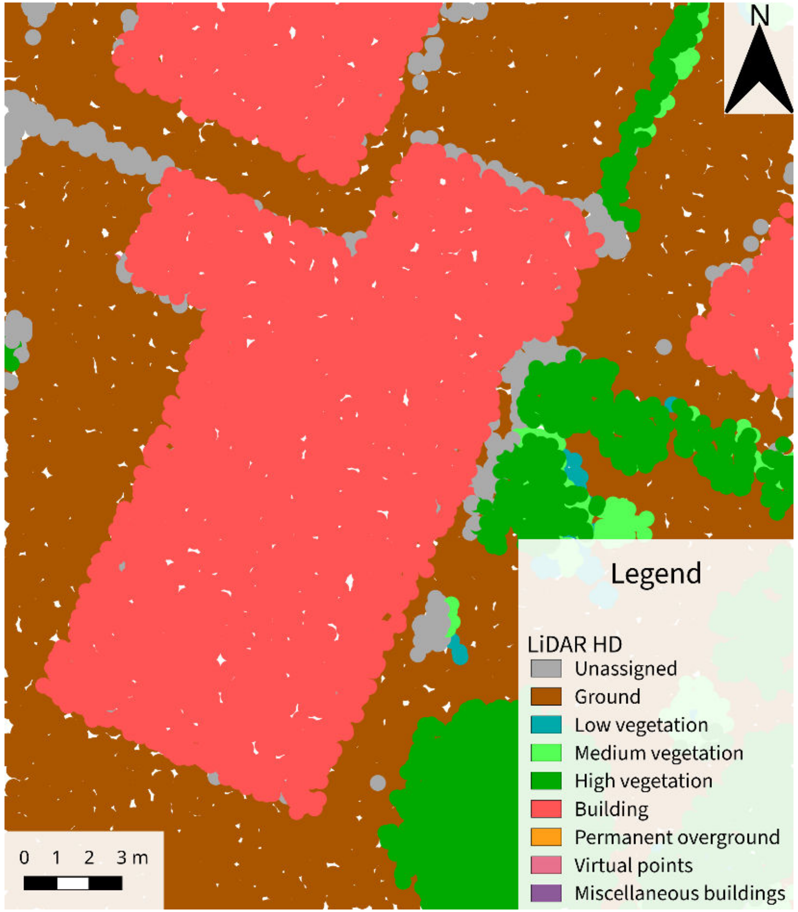
(d) $\alpha = 0.20$



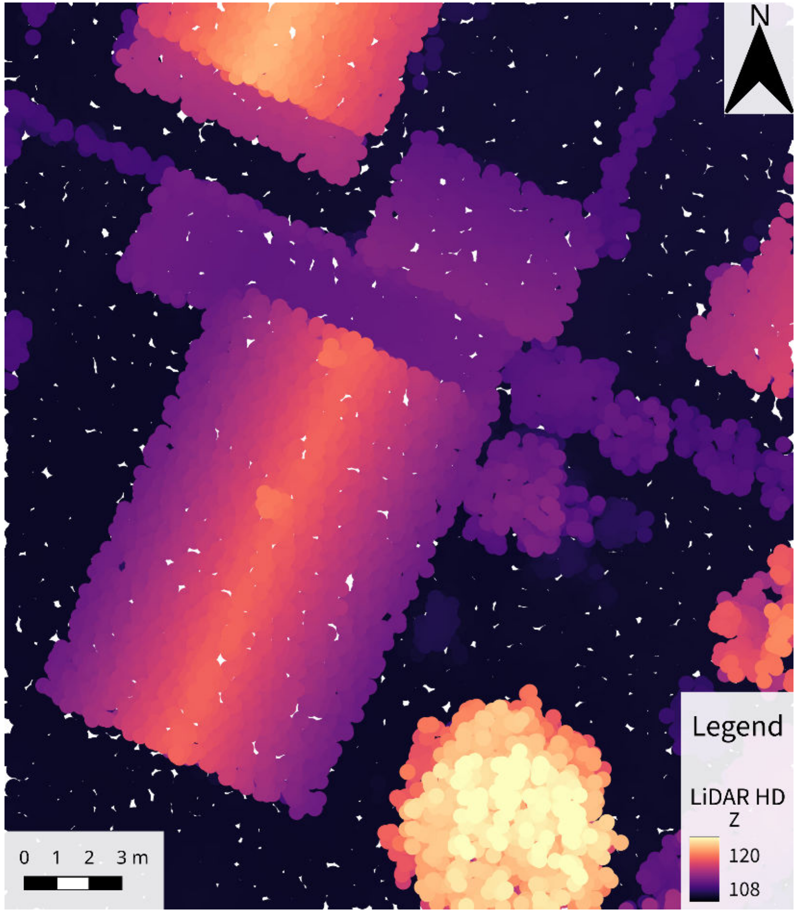
(e) $\alpha = 1.00$

Figure 9: Matching a polygon to half of its shape with points with different values of the regularization parameter α.

Illustration with a real building



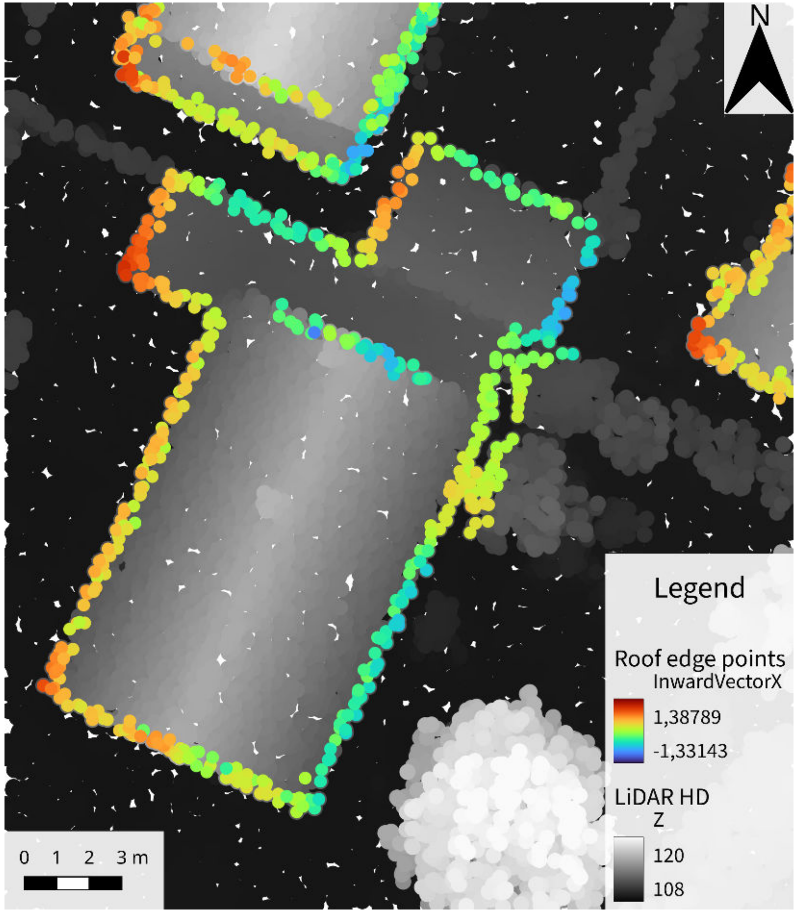
(a) Coloured by classification.



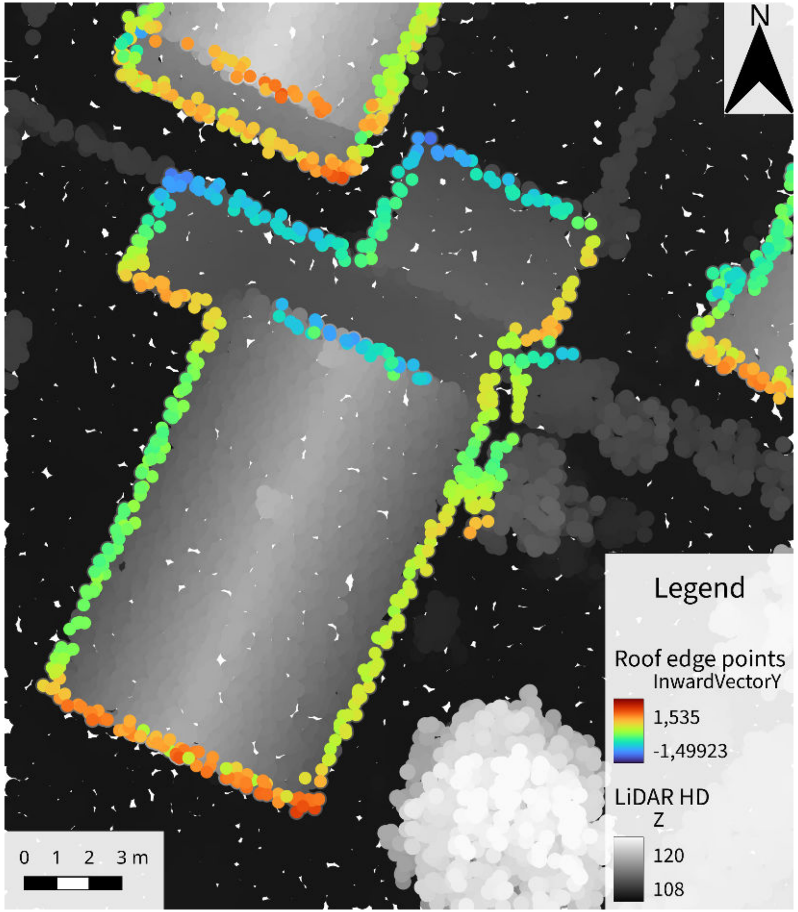
(b) Coloured by height.

Figure 10: The LiDAR HD data.

Illustration with a real building



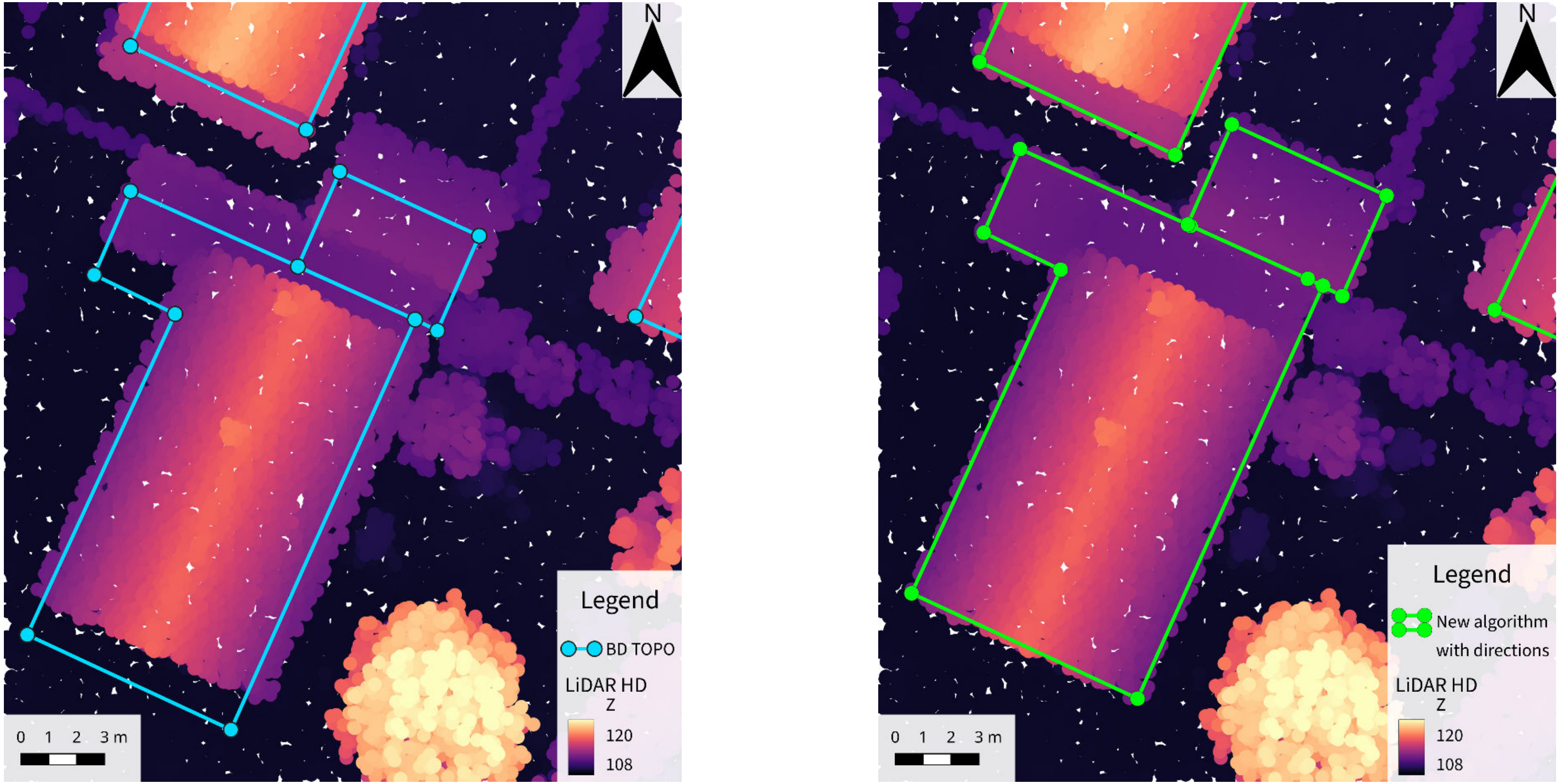
(a) Coloured by the X component.



(b) Coloured by the Y component.

Figure 11: The detected roof edge points coloured by their inward vector.

Illustration with a real building



(a) Initial outlines in the BD TOPO.

(b) Final roofprint produced by the algorithm.

Figure 12: Comparison of BD TOPO outlines and roofprints computed with our algorithm.

Footprints

Footprints evidence

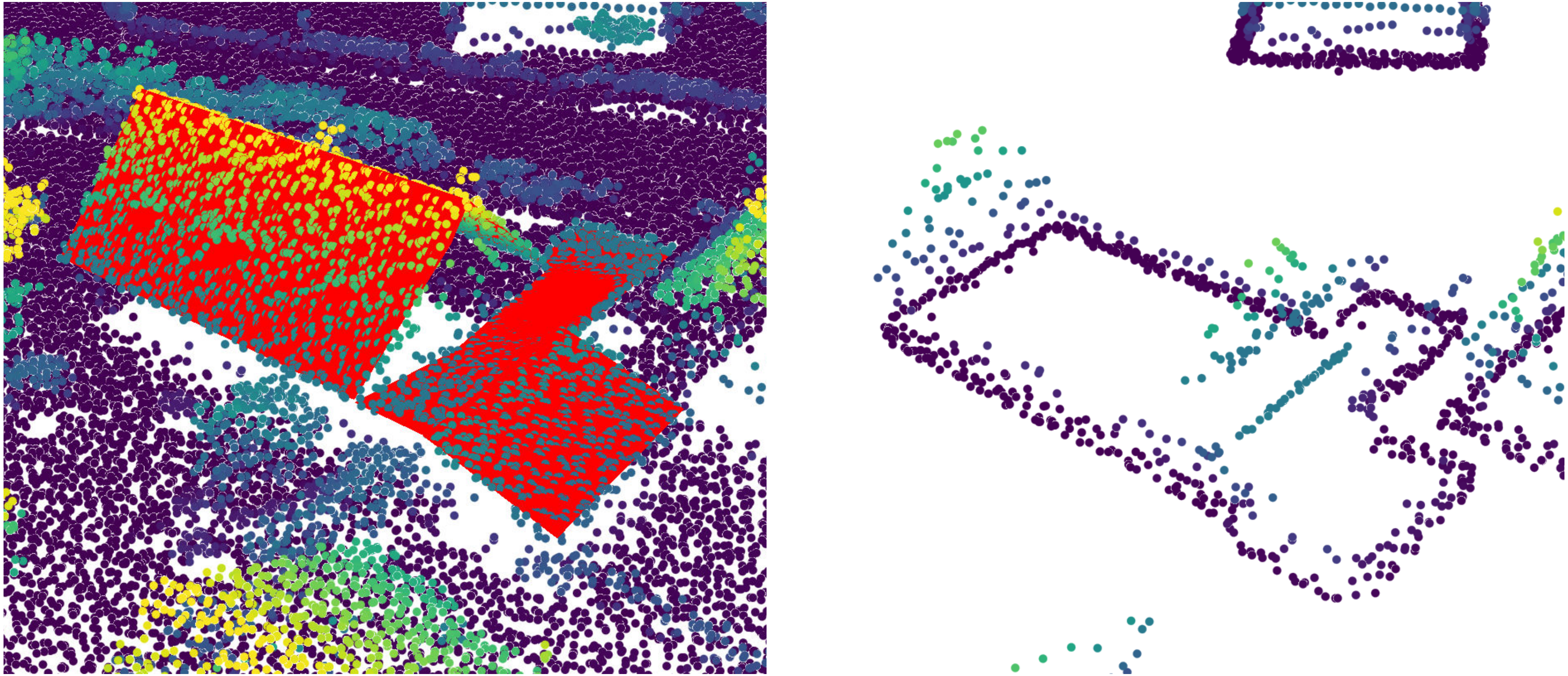


Figure 13: Illustration of the 3D roof structure and the selected points for the footprint computation.

Illustration with a real building

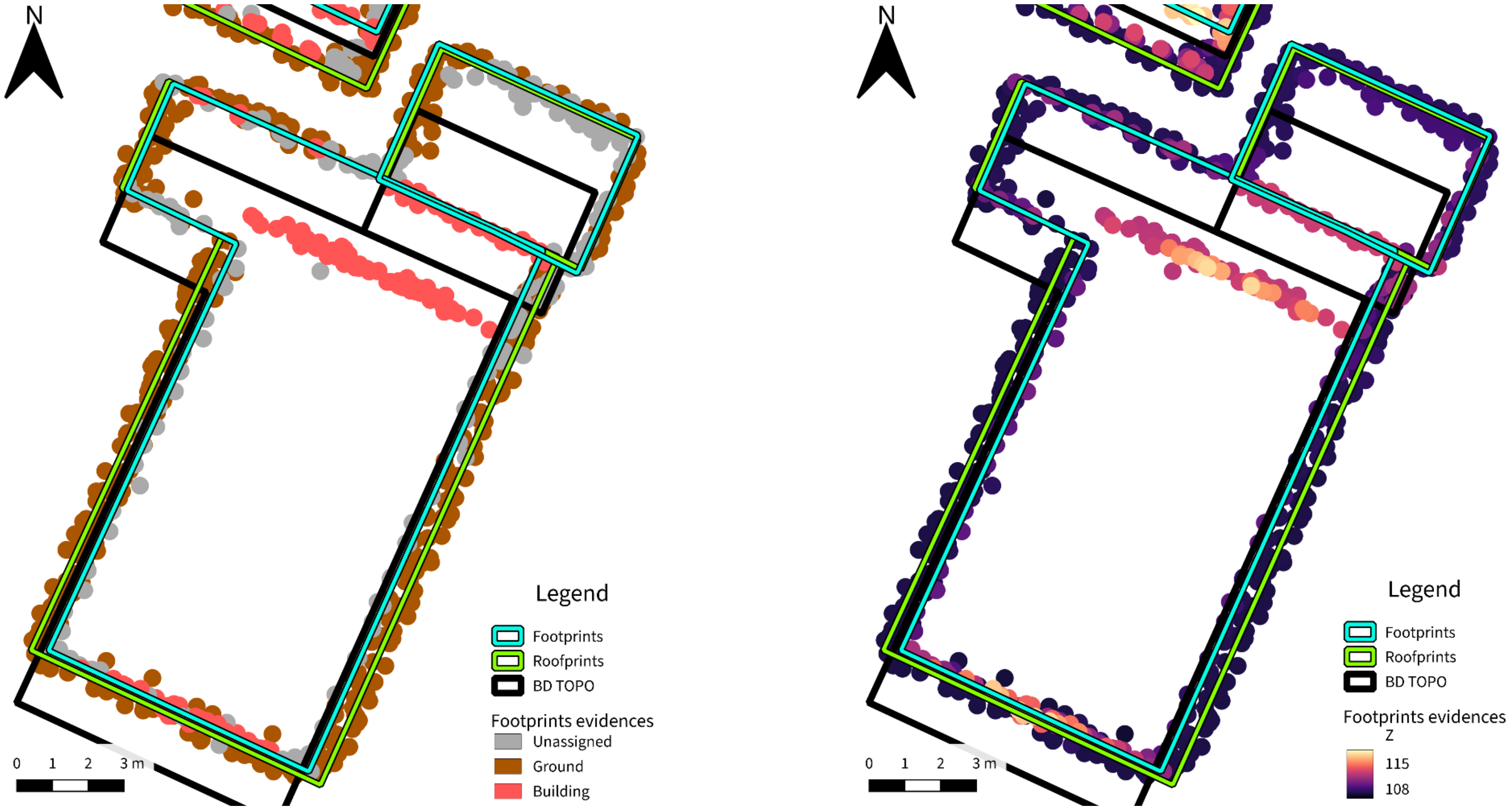


Figure 14: Illustration of the computed footprints.

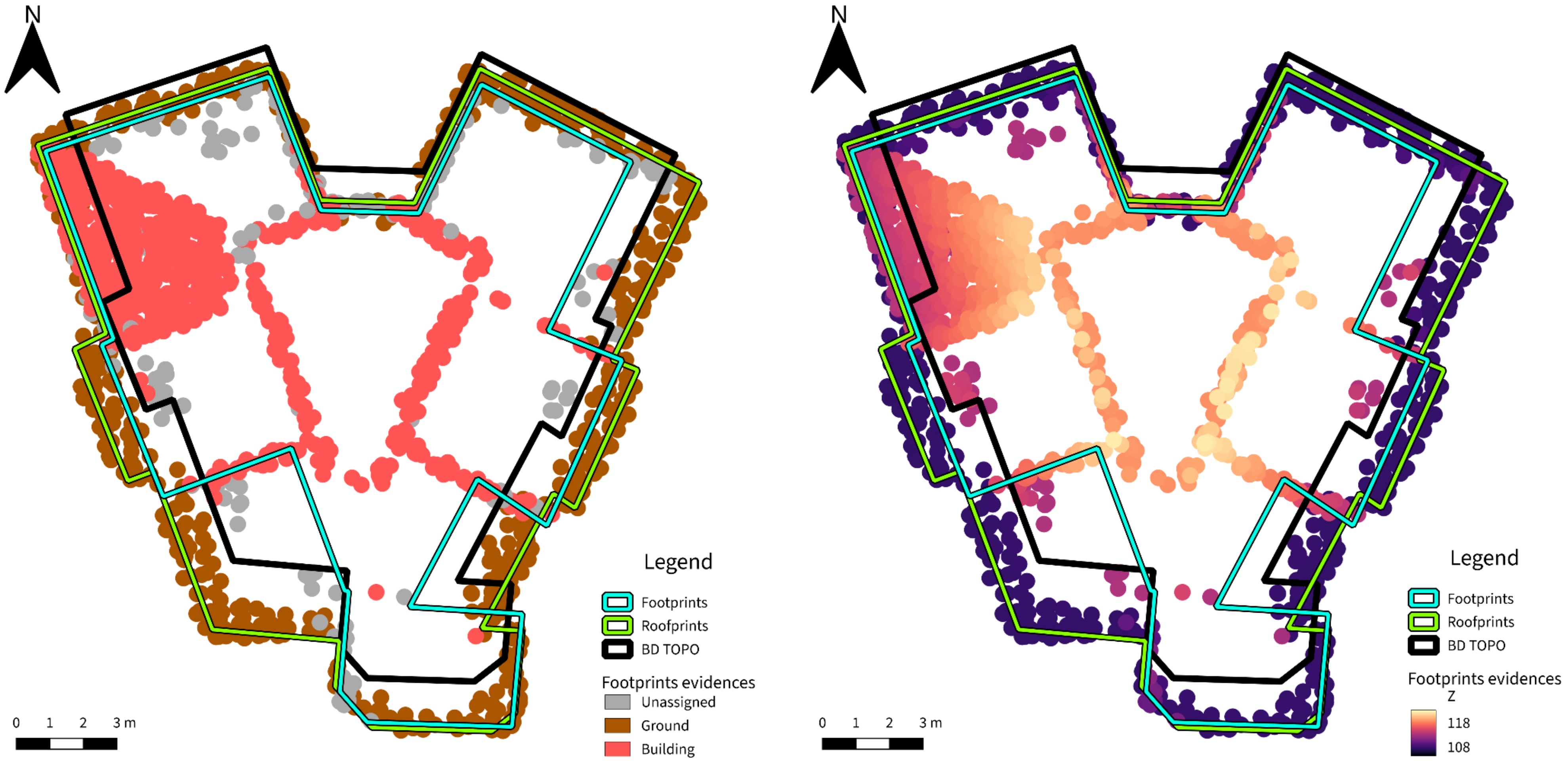


Figure 15: Illustration of the computed footprints.

Conclusion

Conclusion

Result of the thesis	Benefit
Roofprint and footprint	More precise computations with 2D data
	LoD2.2 → LoD2.3
Better georeferencing	Better visualisation in context
	Better 3D roof models

Thank you for your attention!

Link to the slides:

https://alexandre-bry.github.io/MSc_Thesis-Report/slides_pages/2026_06_26-A4.html

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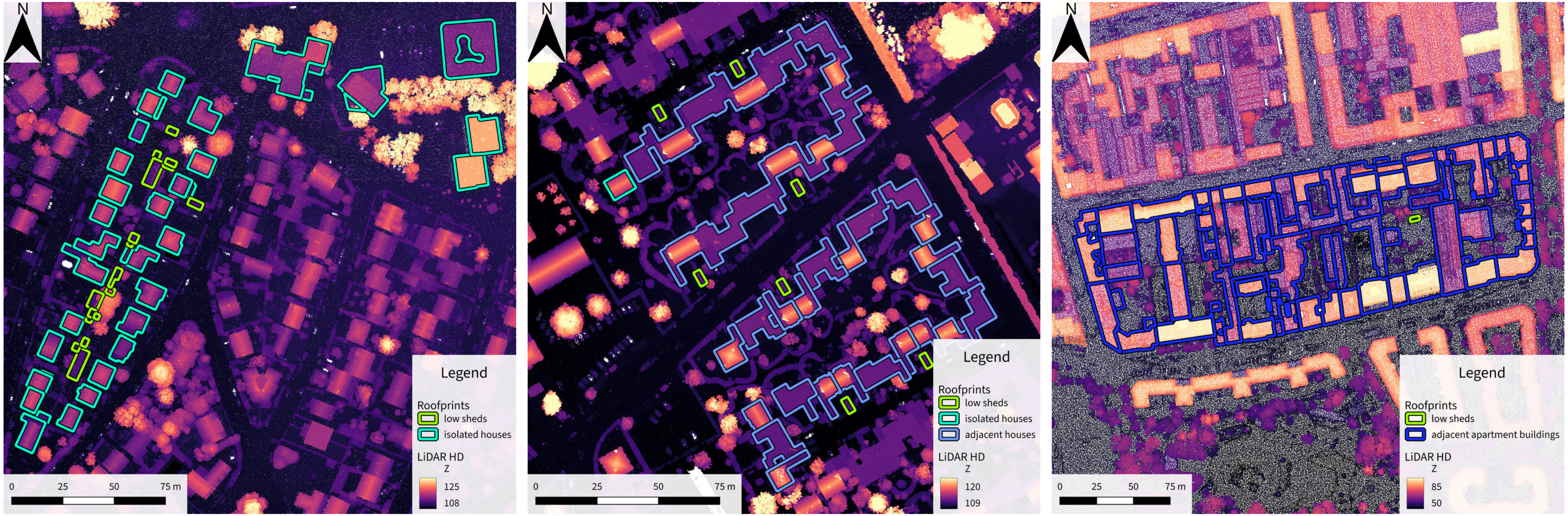
References

Biljecki, F., Ledoux, H., & Stoter, J. (2016). An improved LOD specification for 3D building models. *Computers, Environment and Urban Systems*, *59*, 25–37. https://doi.org/10.1016/j.compenvurbsys.2016.04.005

Wu, T., Vallet, B., Brédif, M., Caraffa, L., & Vosselman, G. (2026). *Reverse engineering LiDAR pulse emission points.*

Appendix

Validation dataset



(a) Area in Ozoir-la-Ferrière with isolated houses and small sheds.

(b) Area in Ozoir-la-Ferrière with mainly adjacent houses.

(c) Area in Paris with mainly adjacent blocks of flats.

Figure 16: Validation dataset.

Validation results

Dataset	IoU	Chamfer (m)	Centroid (m)
BD TOPO	0.735	0.604	0.939
Rfpt 1 iter	0.842	**0.331**	**0.541**
Rfpt 2 iter	0.851	0.335	0.548
Rfpt 3 iter	**0.853**	0.342	0.566

(a) Whole dataset.

Dataset	IoU	Chamfer (m)	Centroid (m)
BD TOPO	0.776	0.557	0.846
Rfpt 1 iter	0.89	0.243	0.388
Rfpt 2 iter	0.902	0.226	0.362
Rfpt 3 iter	**0.905**	**0.22**	**0.354**

(b) Whole dataset except the “low sheds” category.

Dataset	IoU	Chamfer (m)	Centroid (m)
BD TOPO	0.497	0.876	1.477
Rfpt 1 iter	**0.562**	**0.842**	**1.426**
Rfpt 2 iter	0.557	0.97	1.631
Rfpt 3 iter	0.549	1.045	1.793

(c) Category “low sheds”.

Dataset	IoU	Chamfer (m)	Centroid (m)
BD TOPO	0.744	0.55	0.681
Rfpt 1 iter	0.888	0.165	0.215
Rfpt 2 iter	**0.935**	**0.114**	0.12
Rfpt 3 iter	**0.935**	**0.114**	**0.117**

(d) Category “isolated houses”.

Dataset	IoU	Chamfer (m)	Centroid (m)
BD TOPO	0.797	0.448	0.638
Rfpt 1 iter	0.901	0.196	0.309
Rfpt 2 iter	0.91	0.175	0.269
Rfpt 3 iter	**0.914**	**0.168**	**0.259**

(e) Category “adjacent houses”.

Dataset	IoU	Chamfer (m)	Centroid (m)
BD TOPO	0.785	0.595	0.994
Rfpt 1 iter	**0.888**	0.297	**0.499**
Rfpt 2 iter	0.882	0.298	0.512
Rfpt 3 iter	0.887	**0.289**	0.503

(f) Category “adjacent blocks of flats”.

Figure 17: Average metrics over different subsets of the validation dataset.

Results

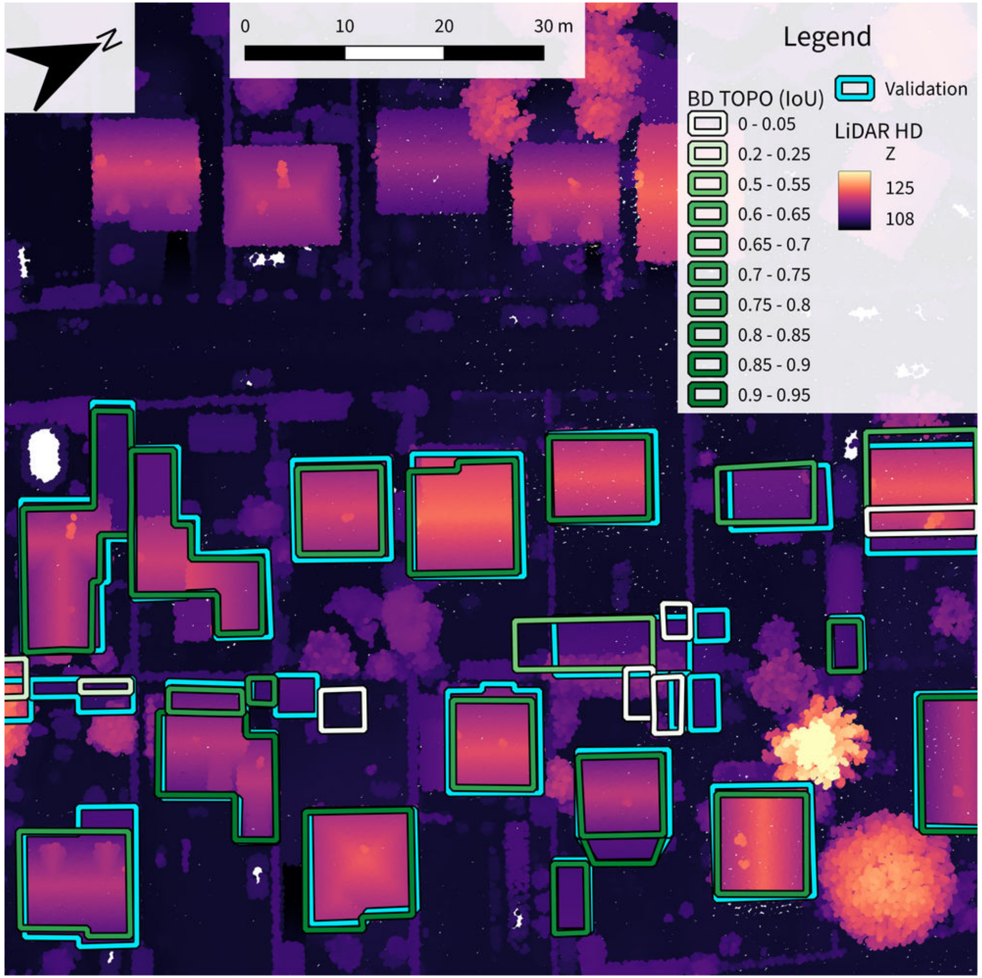


Figure 18: BD TOPO.

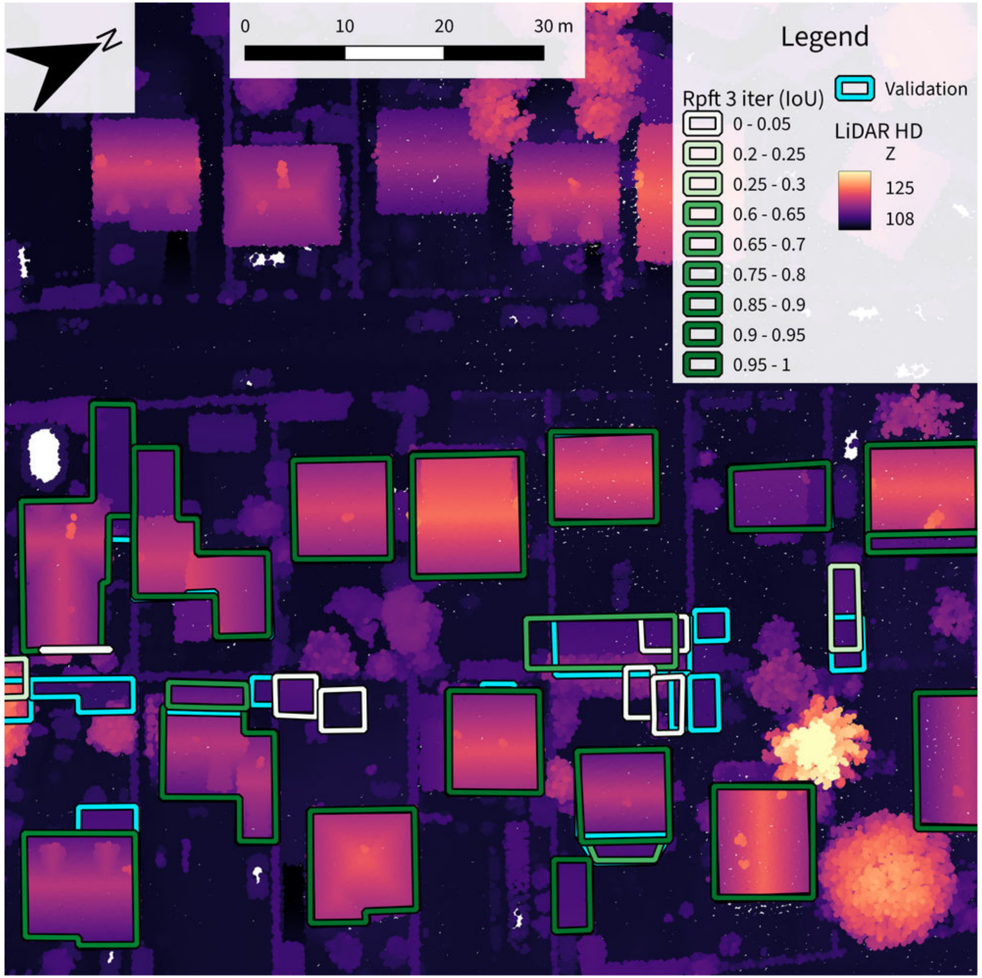


Figure 19: Roofprints after 3 iterations.

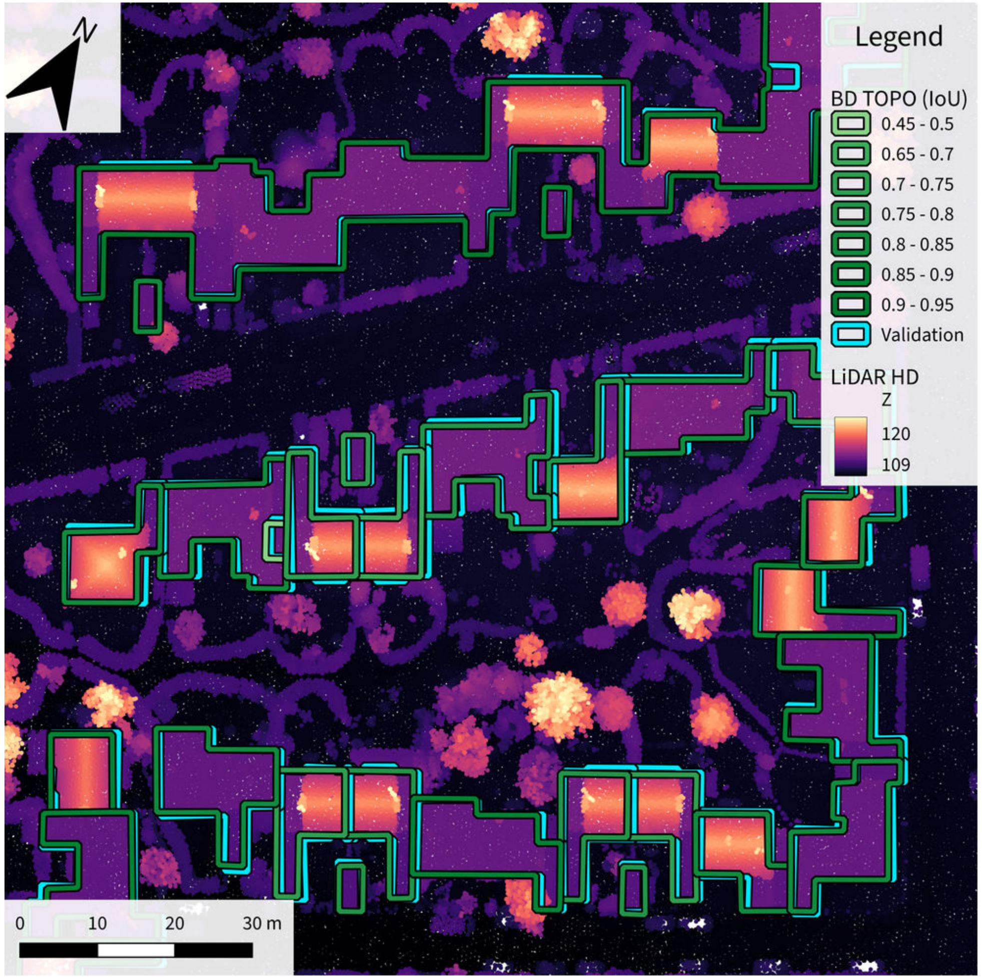


Figure 20: BD TOPO.

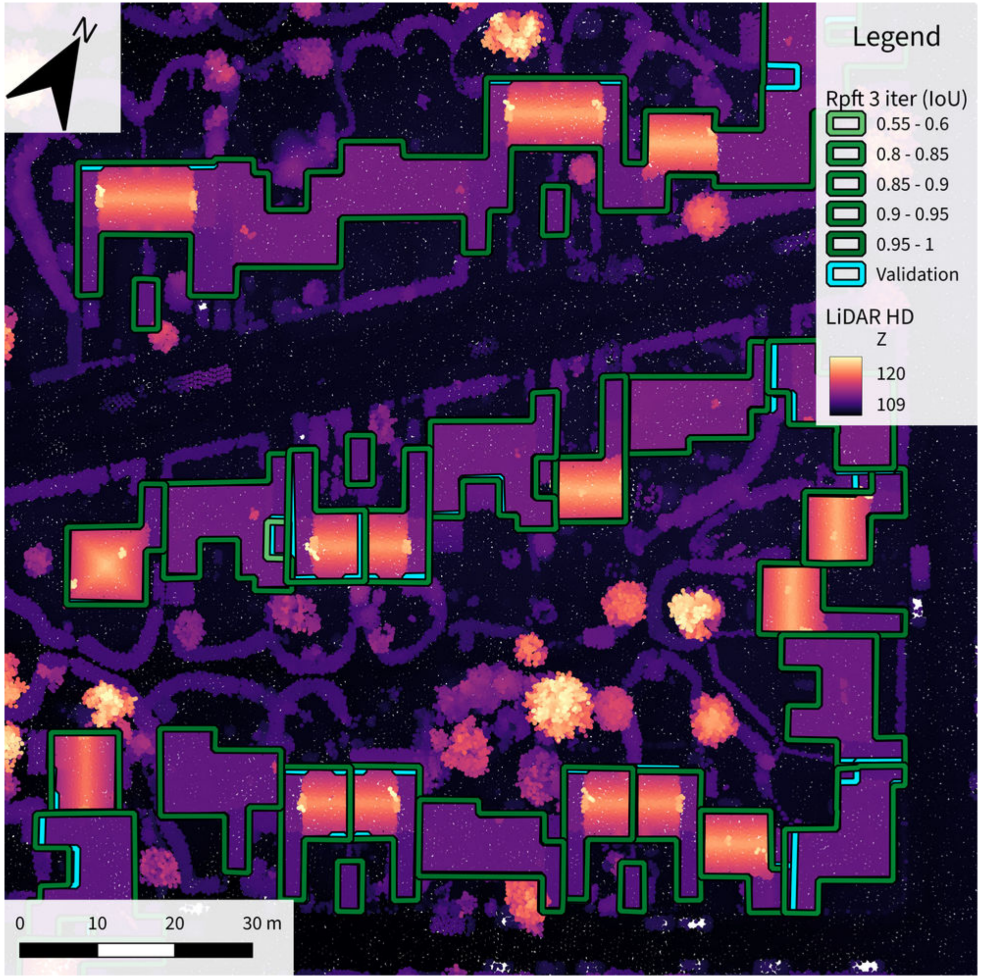


Figure 21: Roofprints after 3 iterations.

Results

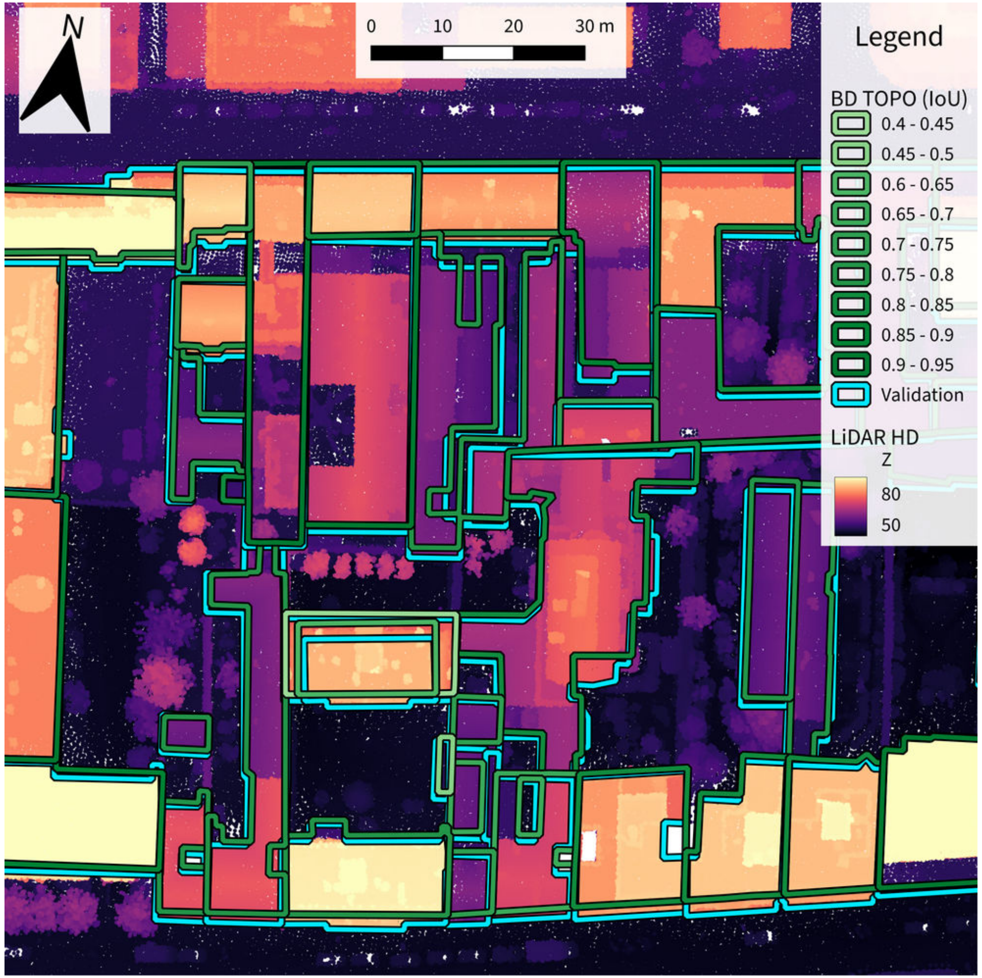


Figure 22: BD TOPO.

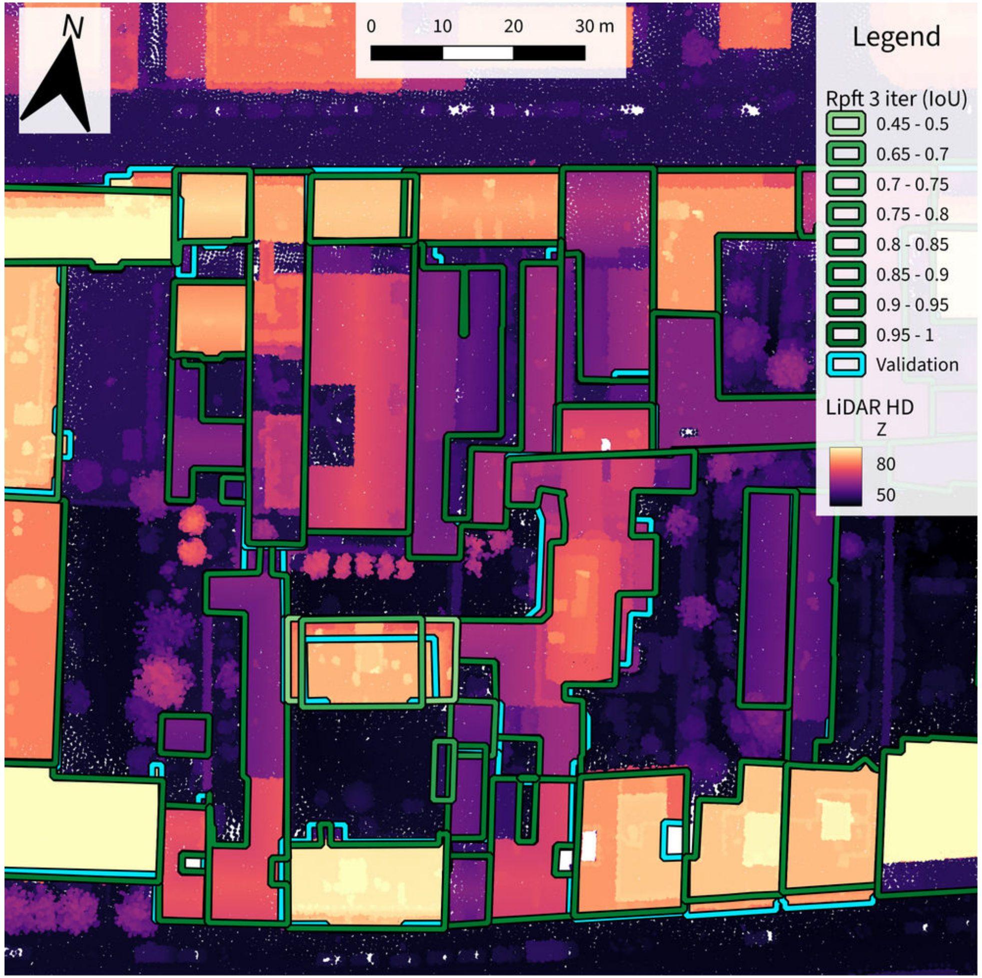


Figure 23: Roofprints after 3 iterations.

Overview of the methodology

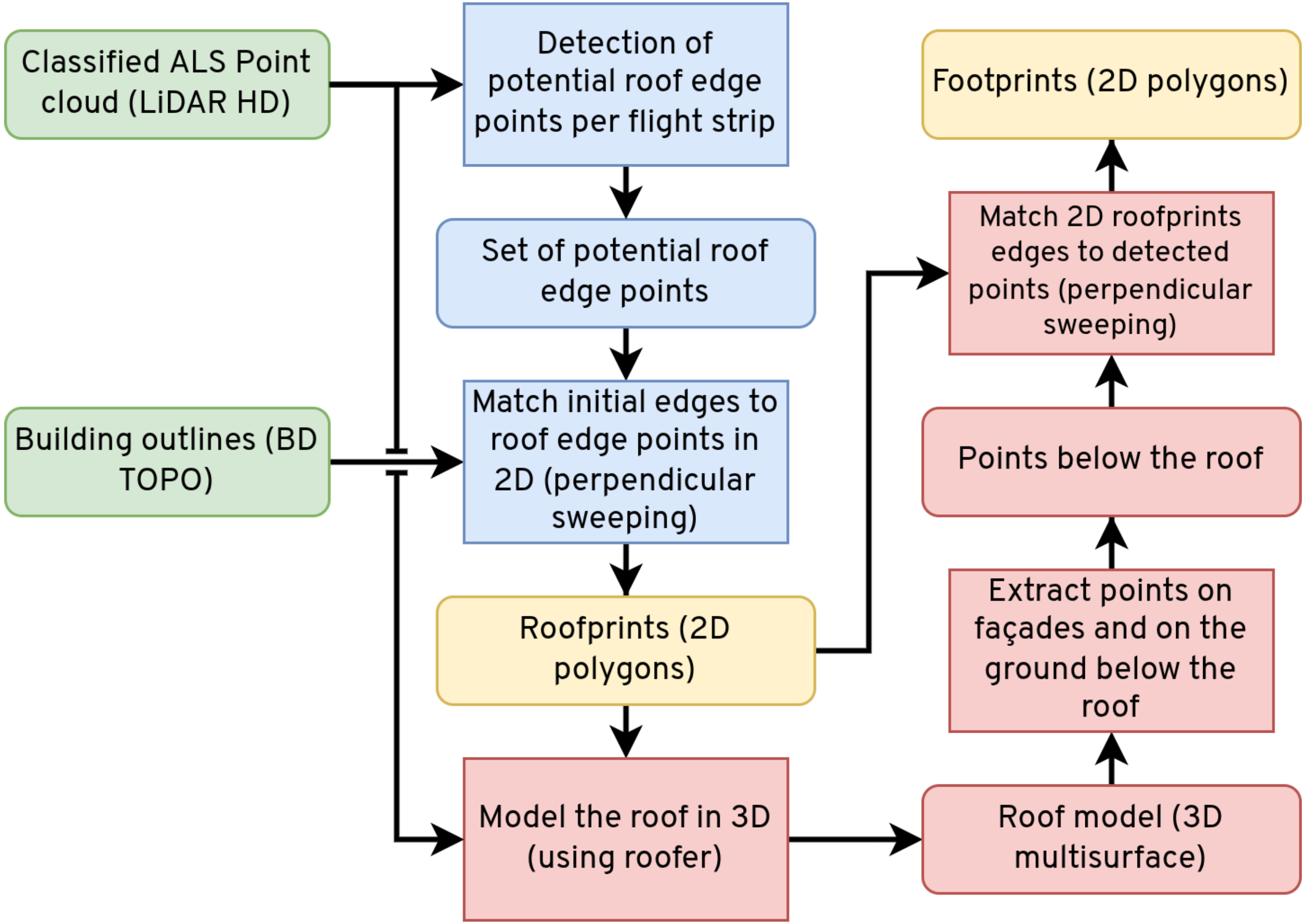


Figure 24: Overview of the pipeline.