

Automatic Reconstruction of Roof Overhangs for 3D City Models

City Models

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INTRODUCTION

Most current 3D city models, created automatically from cadastral and remote sensing data and represented in CityGML [1], do not include roof overhangs, although these overhangs are very characteristic for the appearance of buildings. We developed an algorithm that procedurally adds such overhangs, see Figure 1, cf. [3]. When a CityGML model is textured, the size of the overhangs is determined by recognizing overhangs in facade textures. In this case, the method only needs an already existing model in CityGML representation. Alternatively, if an additional point cloud (e.g., from airborne laser scanning) is available, this cloud can be utilized to calculate the overhang sizes. We compare the results of both methods. The C++ source code is available at https://github.com/SteffenGoebbels/citygml_overhangs.

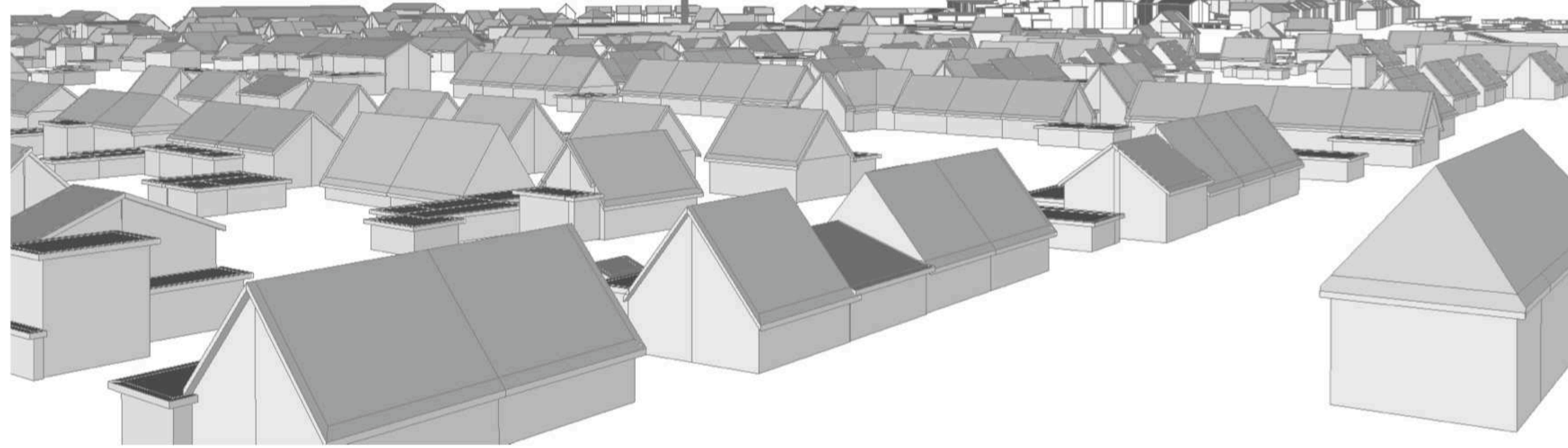


Figure 1: Overhangs were added to a model provided by Geobasis NRW.

ALGORITHM

- The first task is to select the roof edges where there may be roof overhangs. This is done with respect to the height of adjacent building parts.
- Then, for each edge candidate, the size of a potentially adjacent overhang is either calculated or set as a default value. To calculate the size, two methods (edges/color) based on CityGML textures (Figures 3, 4, 7) and one method based on additional airborne laser scanning point clouds are used (Figure 8). If a point cloud is available, the size is estimated from the distances of a farthest inlier and a nearest outlier with respect to the adjacent roof plane, cf. Figure 8.
- Now, the overhangs can be constructed in a generic way using the sizes, see Figure 2.

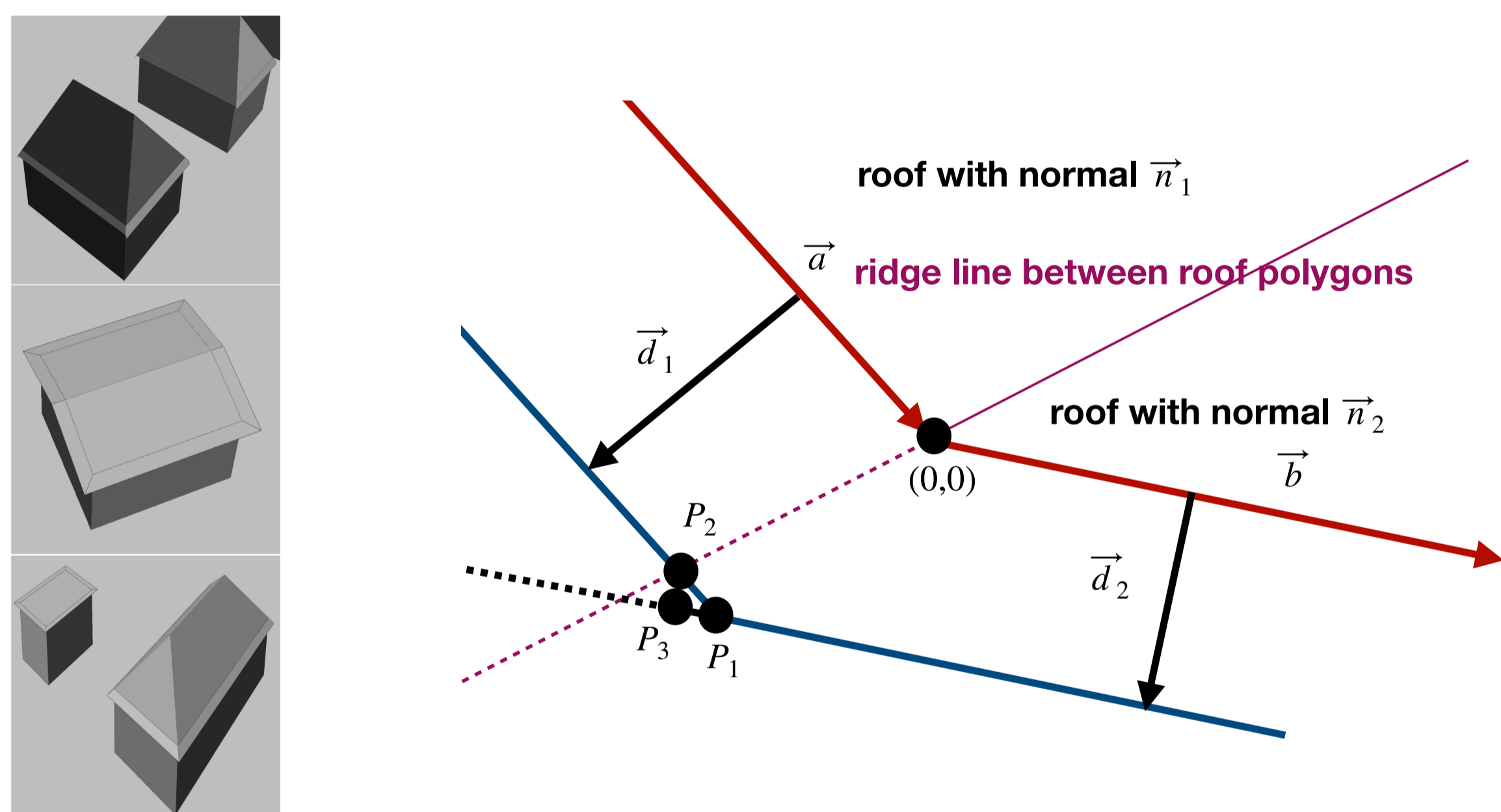


Figure 2: Generic construction of connected overhangs.

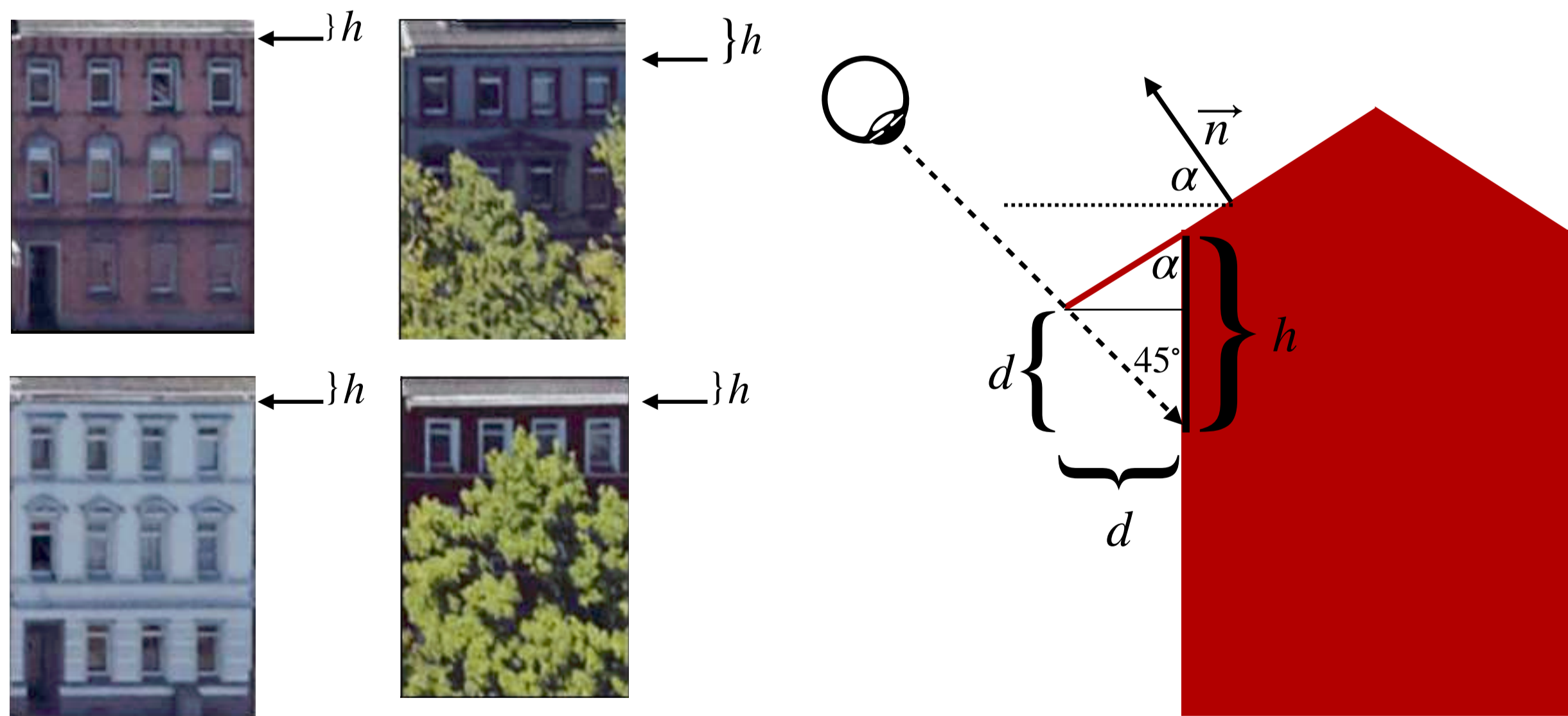


Figure 3: Overhangs with height h are visible in facade textures. From that height, the size d of an overhang with normal \vec{n} can be estimated.

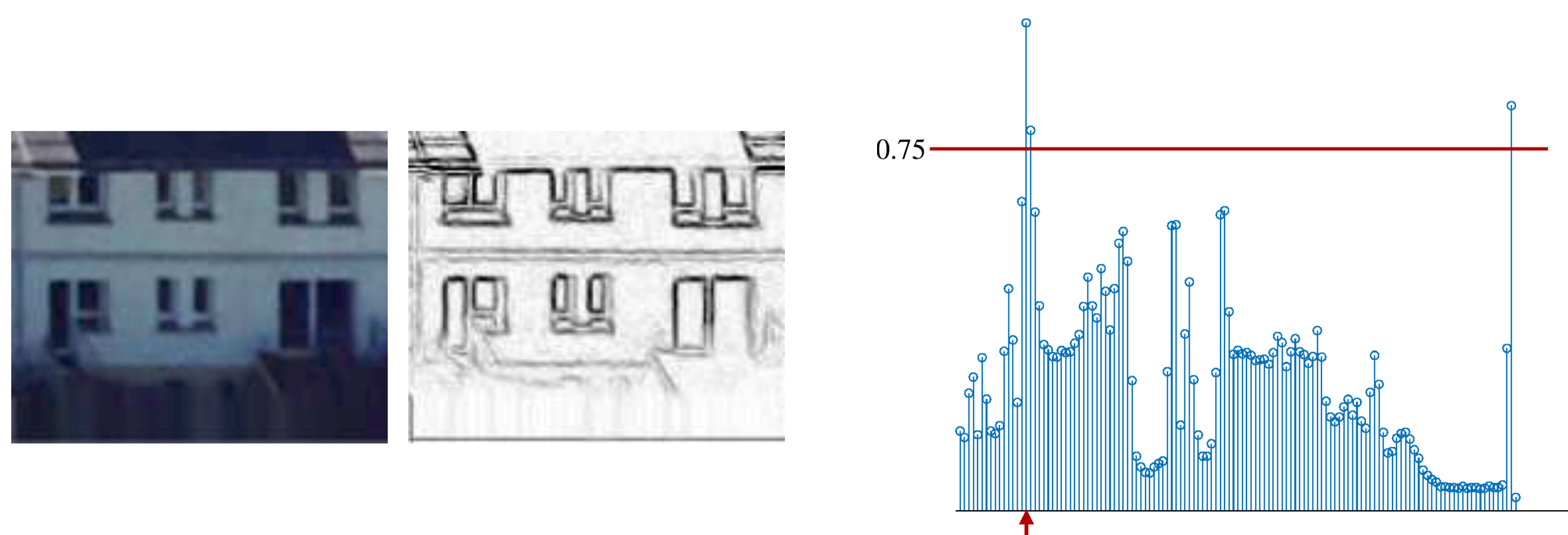


Figure 4: Detection of roof regions with edge histograms.

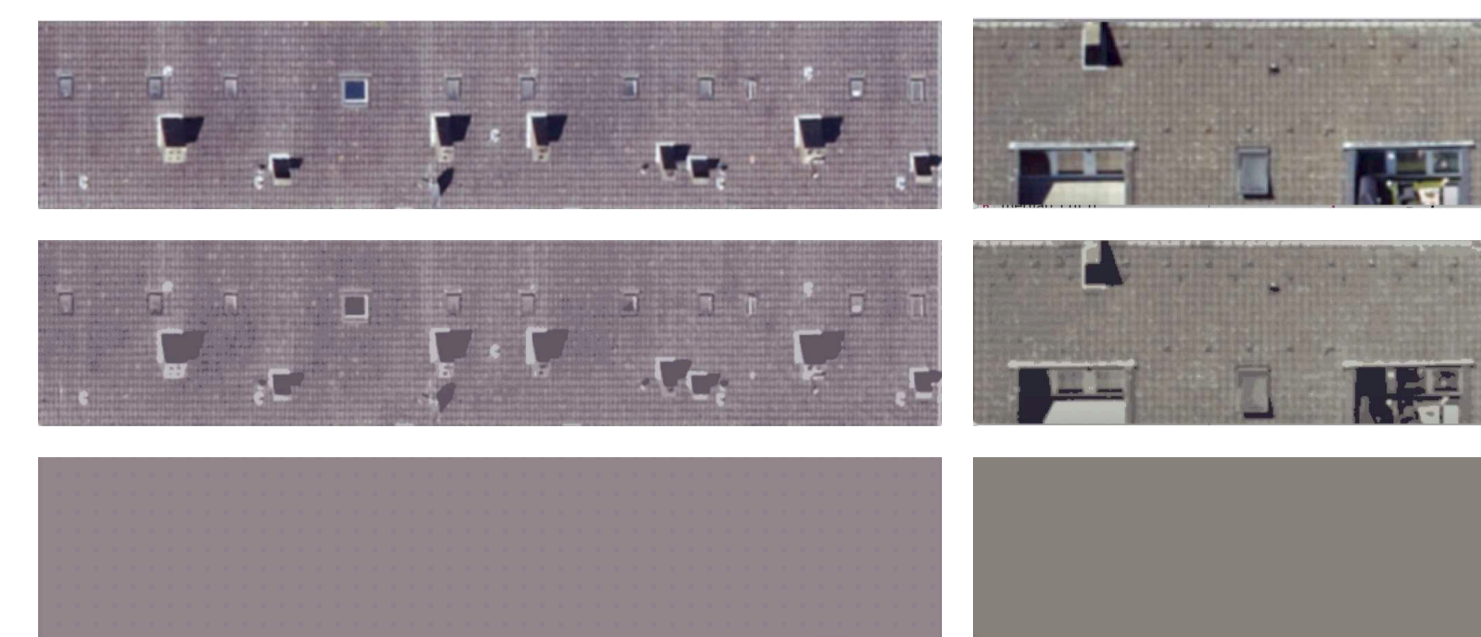


Figure 5: From top to bottom: original roof texture, texture reduced to eight colors with [2], and dominant color.

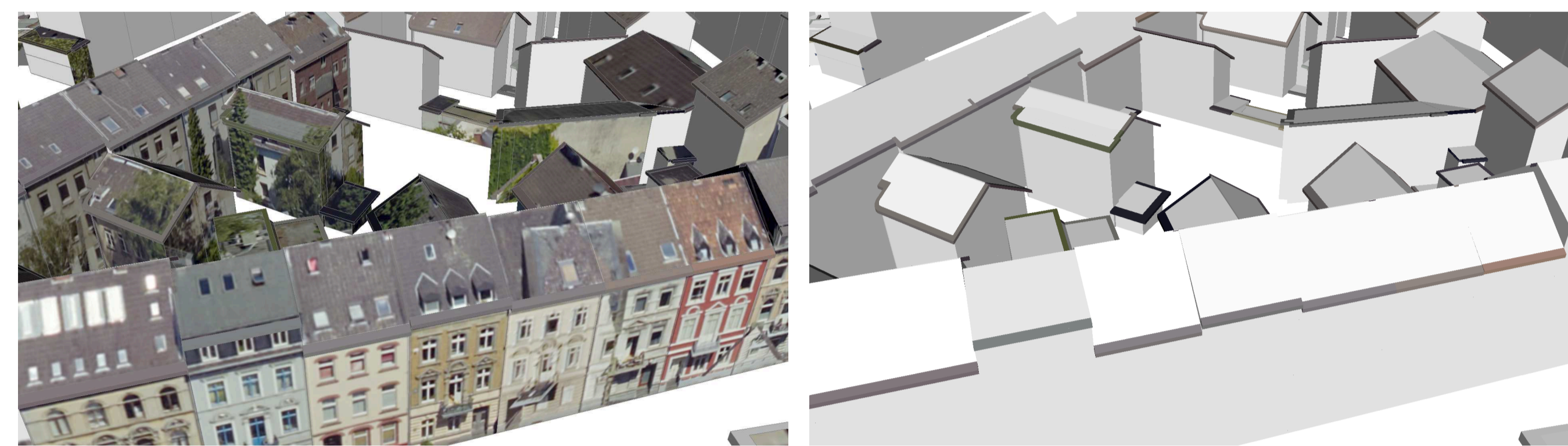


Figure 6: Overhangs painted with the main color of the corresponding roof facet.



Figure 7: The blue lines separate the roof and facade based on an edge image, the red lines separate the dominant colors of the roof and facade, cf. Figures 5, 6

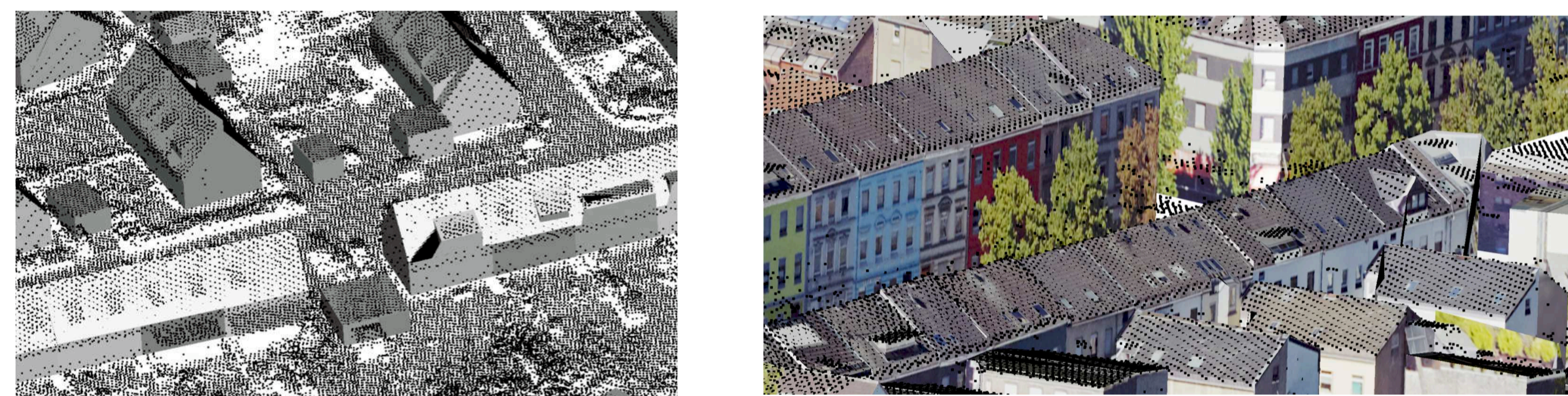


Figure 8: Matching of an airborne laser scanning point cloud with an LoD 2 city model.

RESULTS

We evaluated the algorithm on one square kilometer around our institute with data from Geobasis NRW:

https://www.bezreg-koeln.nrw.de/brk_internet/tim-online/index.html

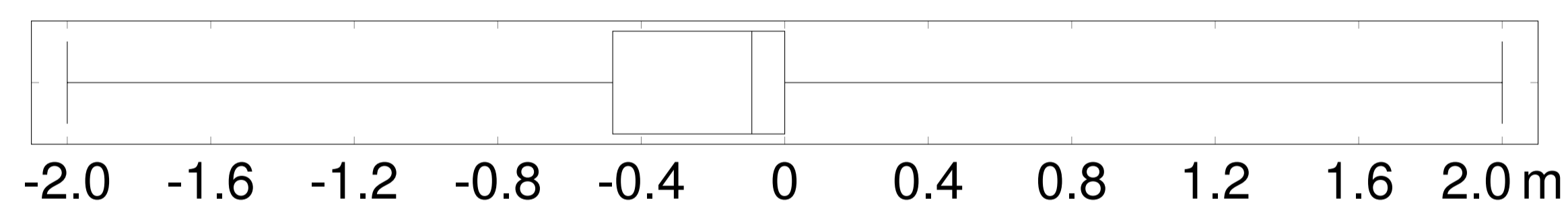


Figure 9: Differences between overhang sizes estimated based on dominant colors and overhang sizes estimated with an edge image (arithmetic mean: -0.306 m).

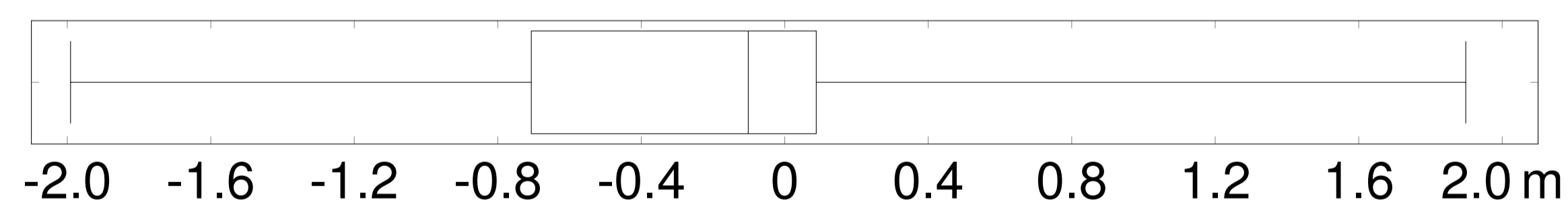


Figure 10: Quality of overhang sizes estimated from sparse airborne laser scanning point clouds: Differences between the farthest plane inlier and the nearest outlier (arithmetic mean: -0.349 m).

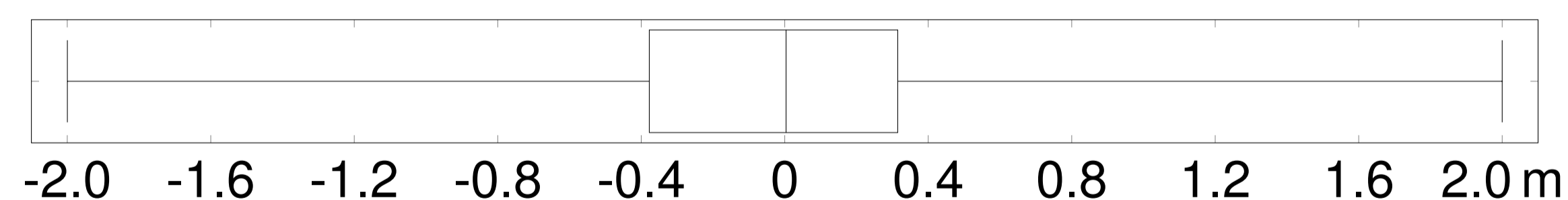


Figure 11: Size estimates based on texture edges minus estimates from aerial laser scanning point clouds (arithmetic mean: 0.006 m).

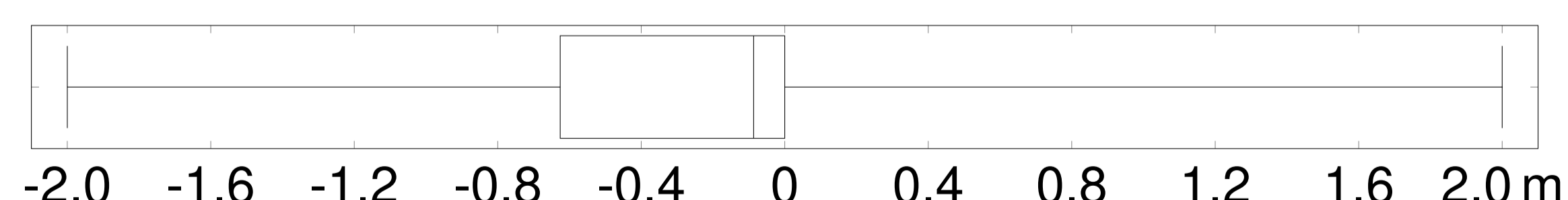


Figure 12: Size estimates from texture colors minus estimates from aerial laser scanning point clouds (arithmetic mean: -0.302 m).

REFERENCES

- [1] Gröger, G., Kolbe, T. H., Nagel, C., and Häfele, K. H. (2012). *OpenGIS City Geography Markup Language (CityGML) Encoding Standard. Version 2.0.0*. Open Geospatial Consortium.
- [2] Heckbert, P. (1982). Color image quantization for frame buffer display. *Computer Graphics*, 16(3).
- [3] Malhotra, A., Raming, S., Frisch, J., and van Treeck, C. (2021). Open-source tool for transforming CityGML levels of detail. *Energies*, 14(24).