Automatic valid LOD2 building models from aerial point clouds with the 3D Medial Axis Transform

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Abstract :

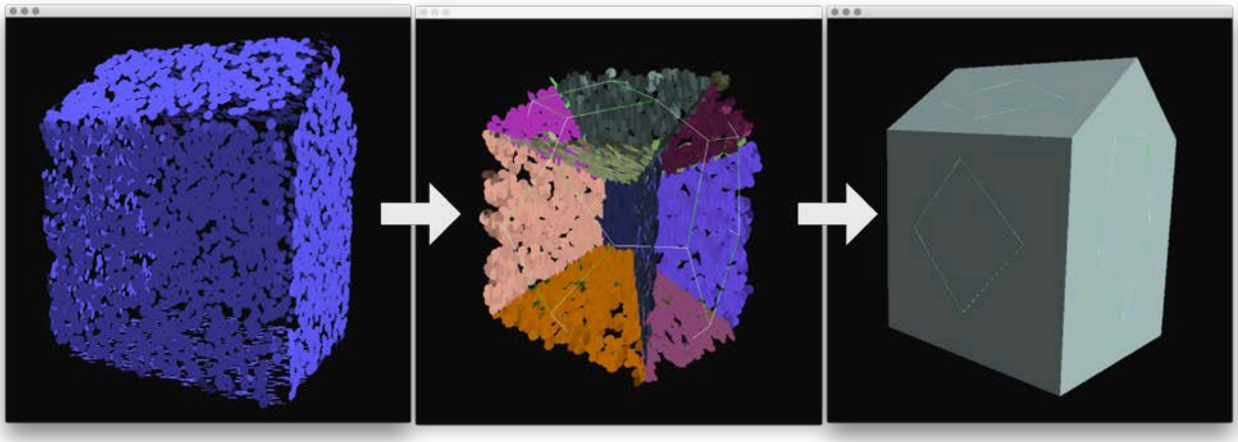
There is an increasing demand for 3D city models throughout the Netherlands for use cases such as heat energy demands modelling, solar panel potential studies, real estate and visibility analyses. Many of these use cases involve spatial operations that require geometrically valid models that have for instance a closed (watertight) volume and correct face orientation. Validity is also essential in the data conversion between different file formats.

In practice we see that the vast majority of city models have significant problems with geometric validity. This may be caused by human modelling errors. But, also in case of existing automated building reconstruction algorithms, geometric validity is typically not considered to be an objective, which means there are no guarantees that the resulting models are valid. Validating and repairing models after reconstruction may be possible, but will require additional processing and —more importantly— especially the repair is actually a rather complex problem in itself.

A more fundamental and effective solution to the problem would be to guarantee geometrical validity in the (automated) algorithms that are used to construct the building geometries. This is trivial for LOD1 reconstruction, but not for LOD2 reconstruction.

To this end I propose a novel method to automatically reconstruct polyhedral LOD2 building models from aerial point clouds based on the 3D Medial Axis Transform (MAT), a skeleton-like descriptor of shape (as opposed to the widely used boundary representation). The prime strength of the MAT is that it is an inherently topological structure that explicitly encodes adjacency between the adjacent faces of a polyhedron, while at the same time having a clear geometrical meaning. This allows us to build a topological data structure on the polyhedron, from which the topology (i.e. adjacency and incidence) of all vertices, edges and faces can be directly derived. And, using the properties of the MAT, we are at the same time able to obtain for each face a set of points that are by definition supporting that face (ie. a plane fit though these points will be very accurate). Reconstructing the polyhedron now becomes a matter of iterating through the elements of the topological data structure while simultaneously deriving the explicit geometry of edges and vertices. This guarantees correct face orientation and water tightness for the resulting model. In addition the method should word for every polyhedron.

I will report on results with a preliminary implementation of the described approach.


Oriented point cloud
MAT + topological data structure
Topological data structure +
reconstructed polyhedron