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Reconstructing LoD3 building models using ray casting and semantic segmentation

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Semantic 3D building models are ubiquitous and are automatically reconstructed up to a level of detail (LoD)2. While LoD2 building models display detailed roof geometries, they lack facade elements such as windows, doors, and underpasses. Such building features become pivotal for numerous applications, such as autonomous driving simulations and enhanced energy demand estimations.

Detailed facade elements can be acquired by vehicle-mounted mobile laser scanners (MLS) that yield dense, street-level point clouds, which, however, do not provide any semantic information; thus their semantic 3D reconstruction poses a challenge.

We propose a strategy to refine existing semantic 3D building models using MLS point clouds by detecting and modeling absent façade elements. To identify missing façade elements, we employ ray casting of laser scanner points and analyze them with a semantic 3D building model using Bayesian reasoning. Three states are identified in the process: conflicted (ray penetrates building surface), confirmed (a hit point is on a surface), and unknown (unmeasured space).

The conflicts serve as geometric cues for localizing missing façade elements. To infer the underlying semantic information of conflicts, we employ a modified Point Transformer neural network on 3D point clouds and Mask R-CNN on textures.

The experiments corroborate the effectiveness (91% detection rate) and robustness (3% false alarm rate) of our method of detecting façade openings. Such refinement strategy also achieved up to 54% higher reconstruction accuracy when compared to standard mesh-based methods (Poisson).