Our approach. In contrast to the majority of facade labeling methods, our approach operates completely in 3D space. (a) image-based SfM 3D point cloud (b) initial point cloud classification (c) facade splitting (d) structure modeling through architectural principles and (e) projected original images onto estimated 3D model. The advantages of pure-3D range from tremendous speed-up to complementarity with 2D classifiers.

We propose a new approach for semantic segmentation of 3D city models. Starting from an SfM reconstruction of a street scene, we perform classification and facade splitting purely in 3D, obviating the need for slow image-based semantic segmentation methods. Our properly trained pure-3D approach produces high quality labelings, with significant speed benefits (20x faster) allowing us to analyze entire streets in a matter of minutes. Additionally, if speed is not of the essence, the 3D labeling can be combined with the results of a state-of-the-art 2D classifier, complementing the performance. Further, we propose a novel facade separation based on semantic nuances between facades. Finally, inspired by the use of architectural principles for 2D facade labeling, we propose new 3D-specific principles and an efficient integer quadratic programming optimization.

<table>
<thead>
<tr>
<th>Method</th>
<th>Accuracy</th>
<th>Timing</th>
<th>Accuracy</th>
<th>Timing</th>
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<td>56.39</td>
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<td>Weak architectural rules on top of Ours+Layer 1</td>
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<td>2D Rules [1]</td>
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<td>Our 3D Rules</td>
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</table>

Table 1: Semantic segmentation of point clouds: Pascal IoU accuracy and timing on the RueMonge2014 dataset. Our approach provides a very fast alternative to previous methods, while providing top results.

Our goal is to estimate a semantically segmented 3D scene starting from images of an urban environment as the input. As a first step, we obtain a set of semi-dense 3D points from standard SfM/MVS algorithms. Next, we classify each point \( P_i \) in the point cloud into one semantic class \( L_i \) (window, wall, balcony, door, roof, sky, shop), using a Random Forest classifier trained on light-weight 3D features. Afterwards, we separate individual facades by detecting nuances in semantic scene understanding (Fig. 1, middle). Finally, we propose architectural rules that preserve principles such as the alignment or co-occurrence of facade elements. These rules have two effects: they improve our—already very good—results, and directly return the high-level 3D facade structure (Fig. 2, bottom).


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