Transformer based 3D Semantic Segmentation of Urban Bicycle Infrastructure

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Motivation

- Cycling is healthy, sustainable, and therefore, desirable
- Good infrastructure can promote cycling
- The bicycle path itself is important
- Question: How do we measure whether it is “good”?
LiDAR & Semantic Segmentation

- LiDAR well-established in road maintenance
- Semantic Segmentation: Class per Point instead of Bounding Boxes in Object Detection

Image Source: Ma et al., 2018, Mobile Laser Scanned Point-Clouds for Road Object Detection and Extraction: A Review
Image Source: Behley et al. 2019, SemanticKITTI: A Dataset for Semantic Scene Understanding of LiDAR Sequences
Holocene X Sensor Bicycle
Data Example
Data Processing

- Extract & match frames of 5 LiDARs
- Combine into single frame using Point Cloud Library
- Align single frames using KISS-ICP
- Label data using SemanticKITTI Labeling tool
Labeled Data
Publicly Available Data Set

- 9486 labeled point clouds
- ~4.5 km of bicycle paths labeled
- SemanticKITTI like data structure
- Available at: https://osf.io/yqrd3/
Model Architecture
Model Training

- Identical for original Cylinder3D and adapted AttentiveCylinder3D
- Adam used
- Temperature Annealing used to alter SoftMax
- Final Results (mean intersection over union):

<table>
<thead>
<tr>
<th></th>
<th>Road</th>
<th>Vegetation</th>
<th>Terrain</th>
<th>Building</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data set share</td>
<td>11.53 %</td>
<td>29.93 %</td>
<td>21.99 %</td>
<td>2.58 %</td>
<td>66.03 % (Sum)</td>
</tr>
<tr>
<td>Cylinder3D</td>
<td>60.23 %</td>
<td><strong>68.77 %</strong></td>
<td>48.61 %</td>
<td>58.00 %</td>
<td>58.90 %</td>
</tr>
<tr>
<td>AttentiveCylinder3D</td>
<td><strong>61.32 %</strong></td>
<td>68.49 %</td>
<td><strong>50.57 %</strong></td>
<td><strong>66.37 %</strong></td>
<td><strong>61.69 %</strong></td>
</tr>
</tbody>
</table>
Example Result

Hand Labeled Ground Truth

Segmented by AttentiveCylinder3D
Outlook: Roughness Evaluation
Contact

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