Online Segmentation of LiDAR Sequences: Dataset and Algorithm

Romain Loiseau\textsuperscript{1, 2}, Mathieu Aubry\textsuperscript{1} and Loïc Landrieu\textsuperscript{2}

\texttt{romain.loiseau@enpc.fr}, \texttt{mathieu.aubry@enpc.fr}, \texttt{loic.landrieu@ign.fr}

\textsuperscript{1}LIGM, Ecole des Ponts, Univ Gustave Eiffel, CNRS, France
\textsuperscript{2}LASTIG, Univ. Gustave Eiffel, ENSG, IGN, F-94160 Saint-Mande, France

Motivations

Autonomous driving:
- Real-time processing of LiDAR sequences is critical.
- Current datasets do not have all sensor’s data at point level.

Contributions:
- HelixNet, a 10-billion points dataset with fine-grained timestamps and sensor metadata and rotation information.
- Helix4D, a compact and efficient spatio-temporal transformer architecture designed for rotating LiDAR sequences.
- SOTA performances with a reduction of over $5 \times$ in terms of latency and $50 \times$ in model size compared to others. Helix4D is as fast as the fastest and as precise as the most precise models.

LiDAR acquisition as a continuous sequence

- 10 billion points spanning over 6 different French cities.
- 20 sequences annotated with a 9-classes nomenclature.
- Point-level information: sensor’s rotation / position / release time $\rightarrow$ method’s real-time readiness assessment.

Semantic Segmentation Results (mIoU)

<table>
<thead>
<tr>
<th>Method</th>
<th>Size (x$10^{6}$)</th>
<th>Full frame (ms)</th>
<th>104ms (Inf.)</th>
<th>5% frame (ms)</th>
<th>21ms (Inf.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SalsaNeXt \textsuperscript{2}</td>
<td>6.7</td>
<td>69.4</td>
<td>55.8</td>
<td>23 ✓</td>
<td>68.2</td>
</tr>
<tr>
<td>PolarNet \textsuperscript{4}</td>
<td>13.6</td>
<td>73.6</td>
<td>58.2</td>
<td>49 ✓</td>
<td>72.2</td>
</tr>
<tr>
<td>Pan. PolarNet \textsuperscript{5}</td>
<td>13.7</td>
<td>—</td>
<td>64.5</td>
<td>50 ✓</td>
<td>—</td>
</tr>
<tr>
<td>SPVNAS \textsuperscript{3}</td>
<td>10.8</td>
<td>73.4</td>
<td>64.7</td>
<td>73 ✓</td>
<td>69.9</td>
</tr>
<tr>
<td>Cylinder3D \textsuperscript{6}</td>
<td>55.9</td>
<td>76.6</td>
<td>66.9</td>
<td>108 x</td>
<td>75.0</td>
</tr>
<tr>
<td>Helix4D (Ours)</td>
<td>1.0</td>
<td>79.4</td>
<td>66.7</td>
<td>45 ✓</td>
<td>78.7</td>
</tr>
</tbody>
</table>

Influence of Slice Size (SemanticKITTI \textsuperscript{1} validation set)

Bibliography

\textsuperscript{1} Behley, J. \textit{et al}., ICCV 2019 ; \textsuperscript{2} Cortinhal, T. \textit{et al}., ISVC 2020 ; \textsuperscript{3} Tang, H. \textit{et al}., ECCV 2020 ; \textsuperscript{4} Zhang, Y. \textit{et al}., CVPR 2020 ; \textsuperscript{5} Zhou, Z. \textit{et al}., CVPR 2021 ; \textsuperscript{6} Zhu, X. \textit{et al}., CVPR 2021