# Point Cloud Segmentation of Infrastructural Steel Elements

DISAL-SP 183

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Enhancing Infrastructure Inspection

- Current solutions **risky**, and **time consuming**

- Innovative approach using **UAV** equipped with **ToF camera**.

- **Real-time segmentation pipeline** capable of efficiently analyzing 3D point-cloud data, to **monitor the integrity of steel infrastructures**.
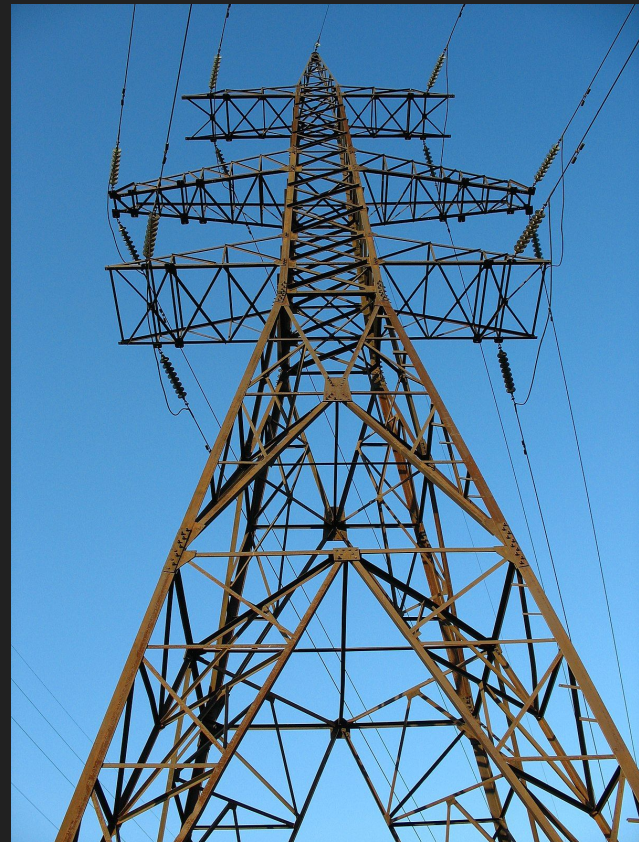
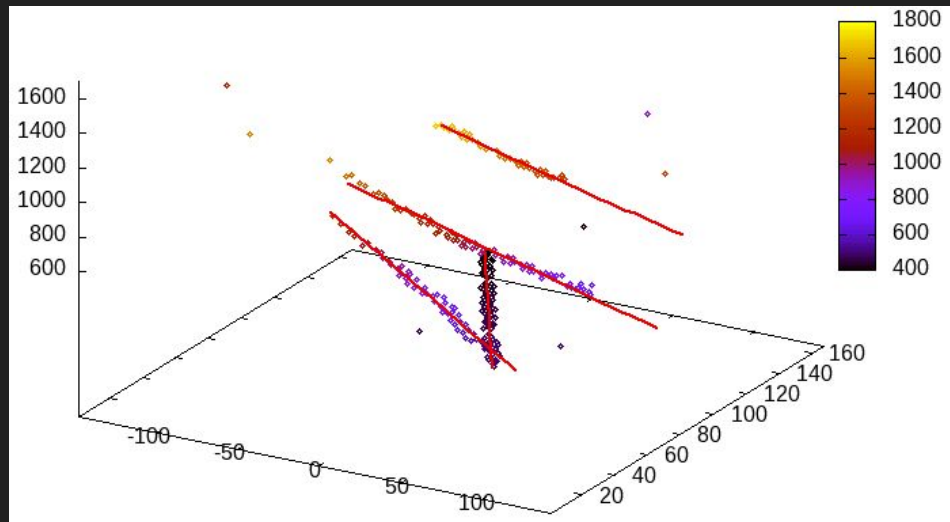# State of the Art in Point Cloud Segmentation

Iterative Hough Transform for Line Detection in 3D Point Clouds, Dalitz, Christoph, Tilman Schramke, and Manuel Jeltsch, 2017
(https://www.ipol.im/pub/art/2017/208/?utm_source=doi)

- Method **detecting lines in 3D point clouds** using the Hough Transform

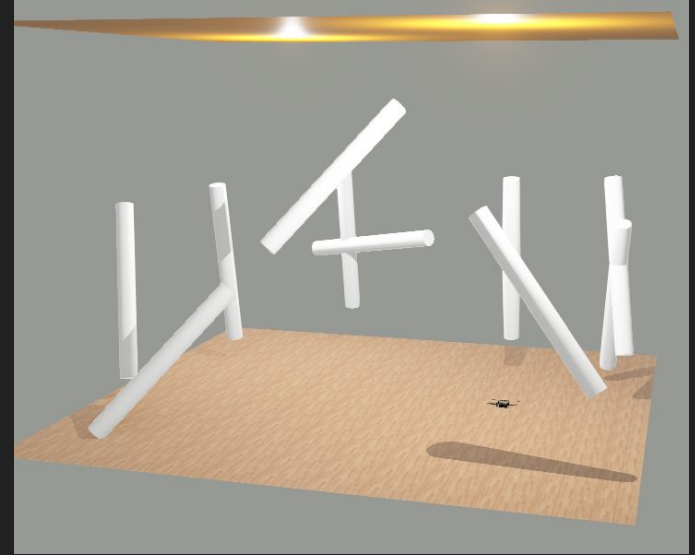Other solution explored (previous SP)

- RANSAC
- DBSCAN
- GMM

Algorithm output

```
nbpoints=78, a=(52.889395,52.335678,460.717949), b=(0.564829, -0.539195, 0.624689)
nbpoints=70, a=(69.556691,28.172875,1018.697143), b=(0.126173, 0.064910, -0.989882)
nbpoints=47, a=(54.826033,9.888771,818.893617), b=(0.116360, 0.020515, -0.992995)
nbpoints=36, a=(75.600461,38.137831,1496.355556), b=(0.110137, 0.070930, -0.991382)
```
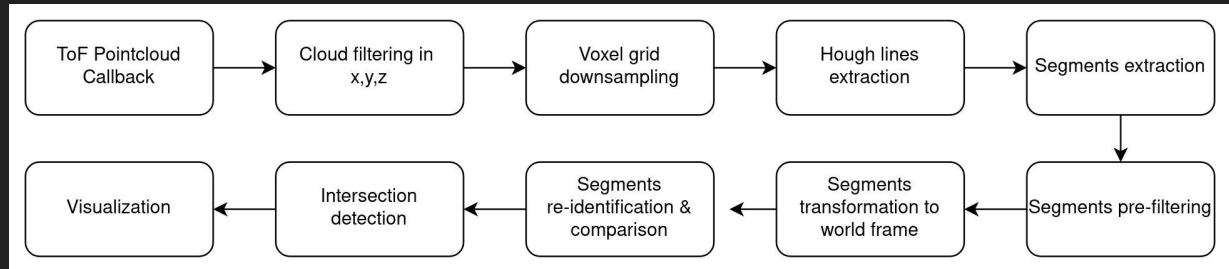
Work done so far

General idea

- **Adaptation** of the **C++ hough-3d-lines library**
- **ROS node** integration
- **Simulation** test


Segmentation pipeline

ToF Pointcloud Callback → Cloud filtering in x,y,z → Voxel grid downsampling → Hough lines extraction → Segments extraction

Visualization ← Intersection detection ← Segments re-identification & comparison ← Segments transformation to world frame ← Segments pre-filtering

Work done so far

- ROS 2 subscriber (topic "`/tof_pc`", "`/pose`")
- **Point cloud TF transform** for visualization purposes
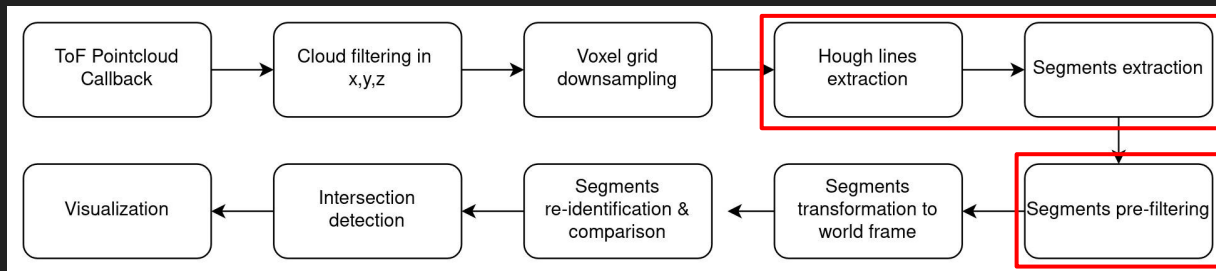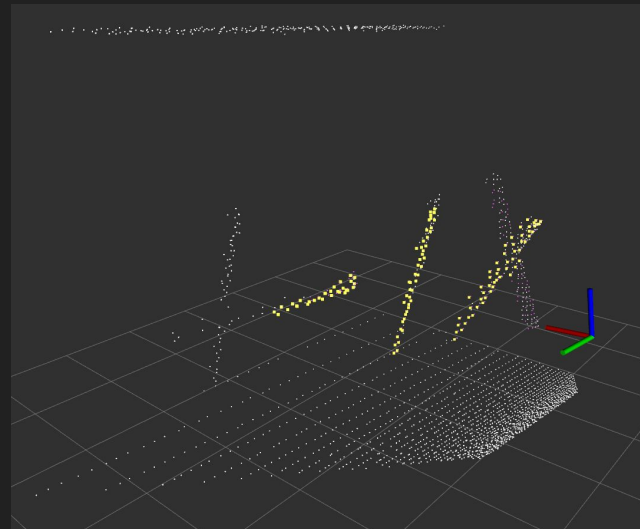 (world frame to drone frame)
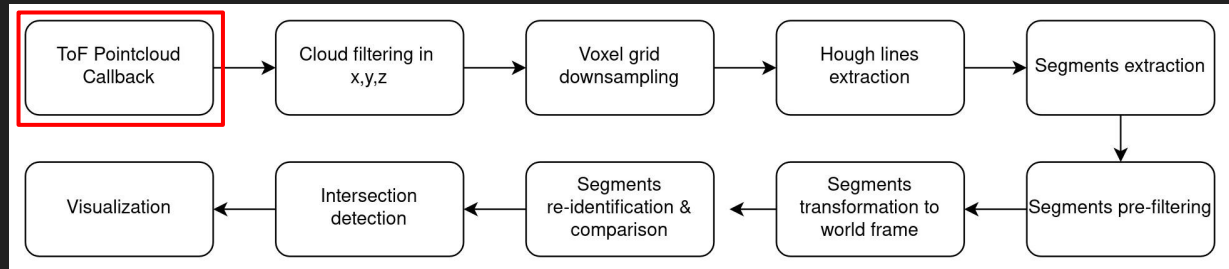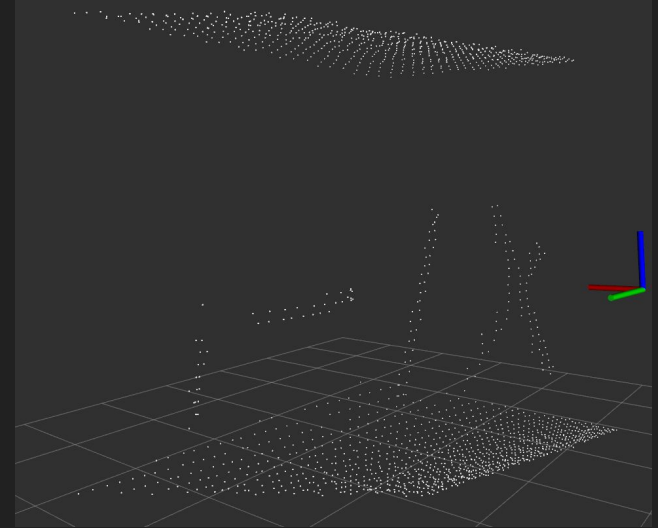
Work done so far

- Cloud distance filtering in x y z
- Cloud voxel grid **downsampling** (PCL library implementation)
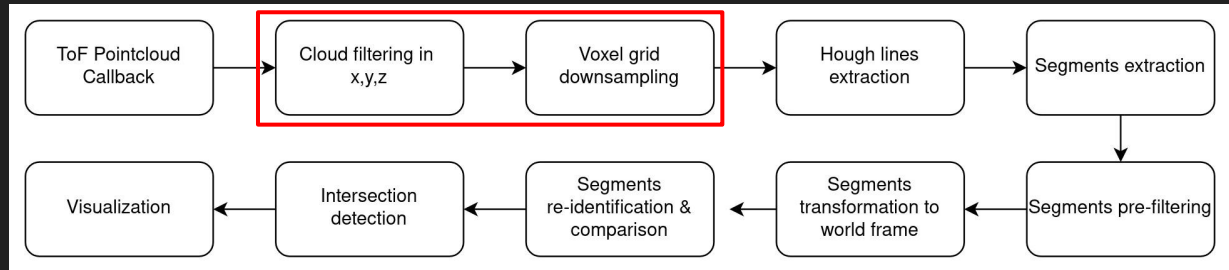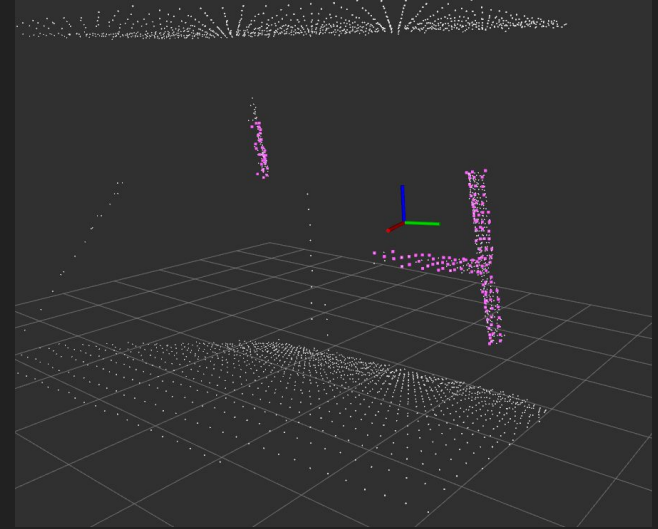
Work done so far

- Hough **line extraction**
- Processing time **optimised** (processing time ~0.02s)
- Segment ends **detection & radius extraction**
- Segment **pre-filtering** (radius size > 0.05m, point distribution)

Work done so far

- Segment transformation from **drone frame to world frame** (using drone position)
- **Segment fusion**
- **Segment intersection**
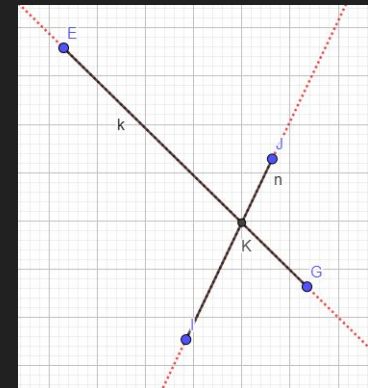- Rviz **visualization** (3 ROS publishers)
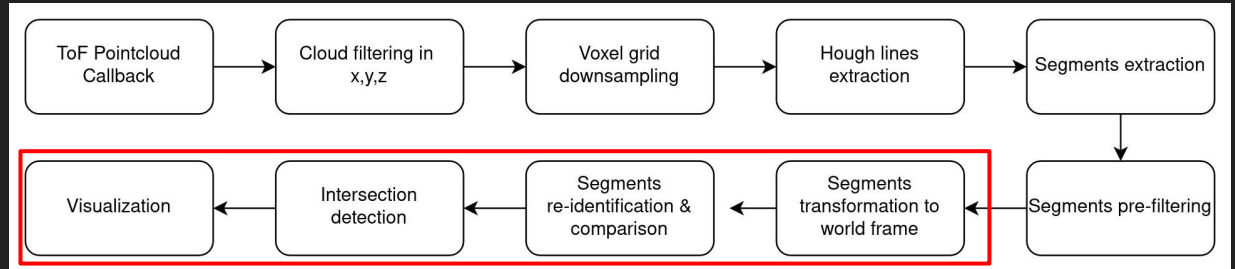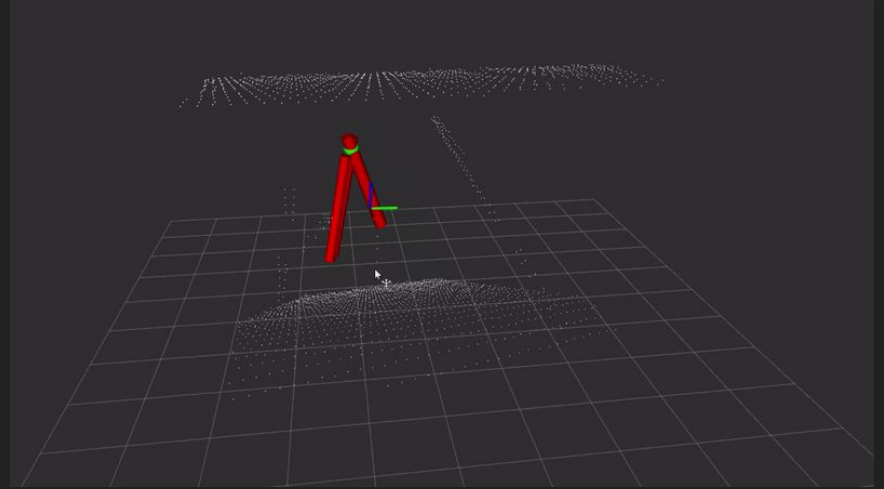
Work done so far

Criterium for **segment fusion**

- Norm of the new segment's projections under tolerance
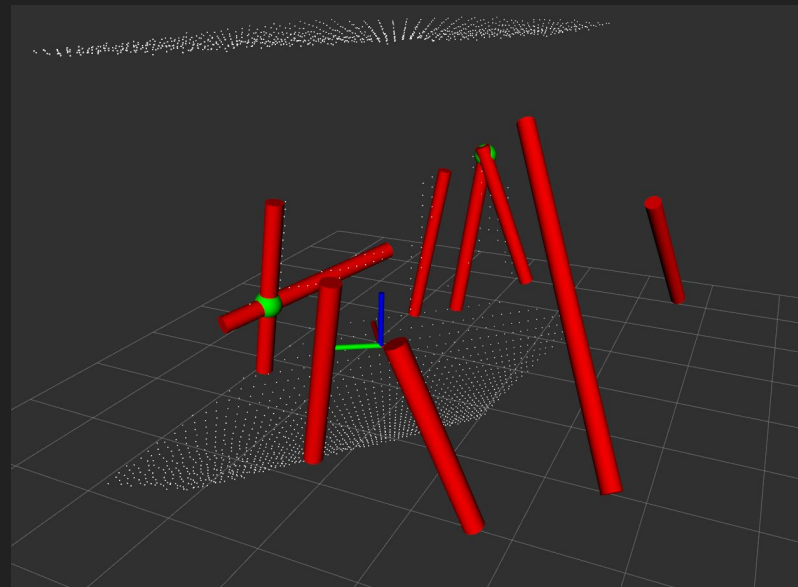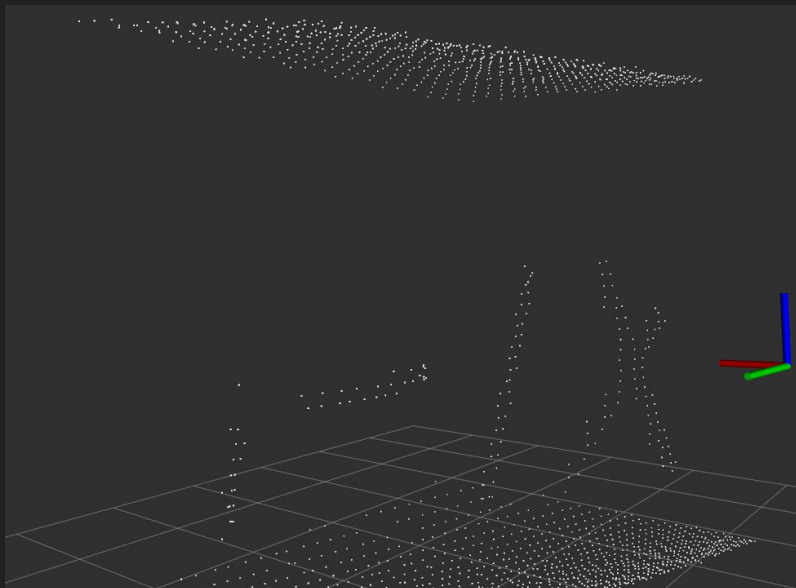- Position of the projected ends of the new segment with respect to the original segment
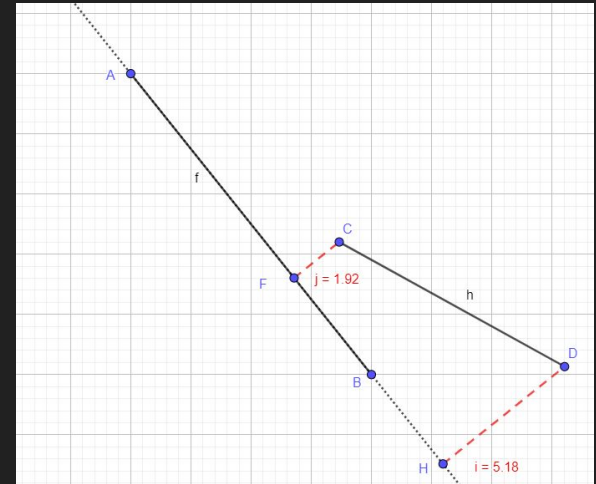
Criterium for **segment intersection**

- Intersection distance
- Crossing position inside both segments

Work done so far

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Future Directions and Improvements

- Improving **segments' fusion**
- **Comparative analysis** with simulations
- **Adaptability** testing in **varied environments**
- **Real-world** application (if time allows)

Q&A