Point Cloud Segmentation of Infrastructural Steel Elements

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Monitoring the integrity of steel structures like bridges or power lines is essential. Traditional inspection methods are slow and carry risks. Utilizing Micro Aerial Vehicles (MAVs) equipped with sensors such as Time-of-Flight (ToF) cameras can revolutionize this process. MAVs enable safer and more efficient inspections, especially in hard-to-reach areas, reducing the hazards for human inspectors and offering an economical approach to maintenance. The primary objective of this project is to develop a real time segmentation pipeline capable of processing and analyzing 3D point-cloud data gathered by MAVs, using ROS and C++.

The process, highlighted in Fig. 1, begins with obtaining raw data from a ToF sensor synchronized with drone pose data. Following an initial pre-processing step, including filtering and the Iterative Hough Transform for line detection, segments are sorted and transformed from the drone frame to the world frame. Additionally, the pipeline integrates segment fusion to combine similar segments and detect intersections between segments. A 3D visualization then displays the computed beams and intersections.

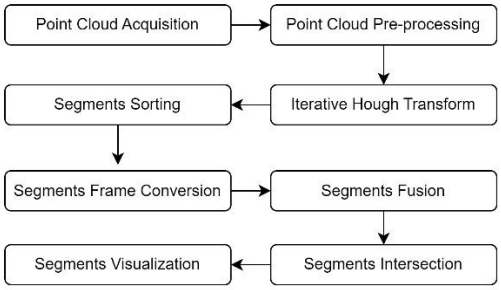

Fig.1 Algorithm Pipeline

In the implementation of the pipeline within the ROS (Robot Operating System) framework, two ROS nodes were implemented, *pointcloud_tfbr* and *pointcloud_seg*. The former is responsible for broadcasting a frame transformation of the point cloud, enabling its visualization from the drone's perspective. The latter handles the entire segmentation pipeline, subscribing to point cloud data, processing it using multithreading for real-time execution, and transforming segments from drone frame to world frame. The algorithm's adaptation includes modifications to the Iterative Hough Transform implementation [1] for integration within a ROS node, optimizing performance by reducing computational redundancy through global initialization of the Sphere object.

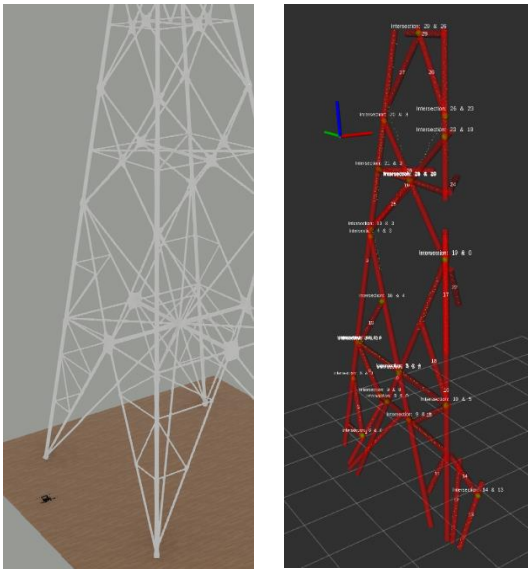

Fig.2 Ground Truth VS Extracted Structure

Key achievements for this project include the implementation of a dynamic threshold strategy for detecting segment similarity and a fusion technique that considers segment quality. Additionally, real-time processing capabilities have been realized. While there is room for improvement, the use of 3D Hough lines in detecting structures turns out to be very promising, opening up new possibilities in the realm of autonomous infrastructural inspection.

[1] C. Dalitz, T. Schramke, M. Jeltsch: "Iterative Hough Transform for Line Detection in 3D Point Clouds." Image Processing On Line 7 (2017), pp. 184–196. https://doi.org/10.5201/ipol.2017.208