SU 2020-2021, SIN, DISAL-SU31 Project Summary

Design, Execution and Analysis of Experimental Campaign for 3D Gas Distribution Mapping

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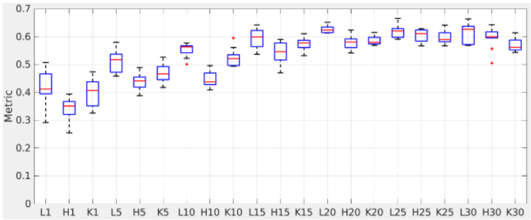
The main focus of this project was to finalize the setup of our clustering-based strategy for Gas Distribution Mapping (GDM) and evaluate its performance in a Webots simulation, in which the source release rate, wind speed, source position, starting point and velocity of the drone are carefully configured. An accurate synchronization of time between the Webots and ROS components of the simulation was also achieved.

A key missing piece in the clustering-based strategy was an accurate formalization of the cluster exiting strategy (i.e., when the robot decides to move from one cluster to the next). Our final choice was to formalize the exiting strategy as a probability problem. When 80 percent of the time assigned to a cluster has passed, check whether the proportion of updated cells containing gas falls below a threshold. If this condition is met, leave the cluster. This exit strategy allows to leave a cluster earlier than the originally allocated time when not a lot of gas cells are present in the cluster, with the objective of freeing up some mission time to explore more informative clusters for longer.

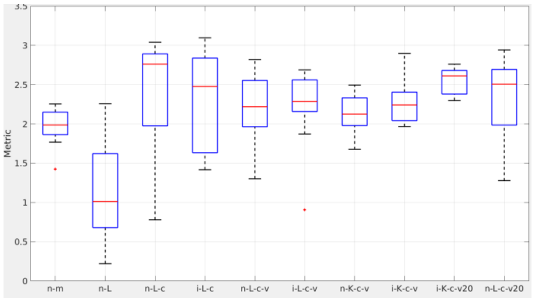


Comparison of different strategies with different number of clusters.

To facilitate the comparison of different strategies, we propose a new metric M to combine the previously separated metrics (coverage, RMSE, shape coverage). The shape coverage metric represents the probability of an updated cell to be identified correctly as containing gas or not according to the ground truth. We conducted many sets of simulation and real experiments, which show that, as the number of clusters increases, the clustering strategy has great impact on the mapping performance, plateauing at around 15 clusters.

The final part of this project focused on optimizing the parameters for Source Term Estimation (STE) algorithm used for Gas Source Localization (GSL) with a random search and implementing a way to declare the final source position. The STE parameters were optimized, greatly improving the performance of the algorithm in simulation. For the source declaration, a method was proposed that finds the local area with maximal density of source location guesses and chooses the average position of them as the final declared source position. The average is computed as a weighted mean, where the lower the STE entropy is for one source position guess, the bigger weight it is attributed to it.

The results indicate that the addition of weighted vectors for navigation will reduce the coverage and thus the overall performance of the algorithm. However, this can be overcome by increasing the number of clusters. The vector method makes the drone focus on searching gas areas, which may cause very high values to be mapped in some zones. This limits the potential of vector method to reduce the RMSE, and slightly decreases shape coverage.



Resulting overall metric for STE+GDM in the proposed methods