SS 2024-2025, SIN-EXC, DISAL-MP57 Project Summary

Distributed Multi-Robot System for Gas Source Localization

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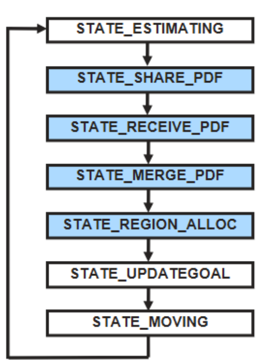
Recent advances in Gas Source Localization rely on Single-Robot, which could be limited, especially in terms of spatial coverage and localization time.

The main goal of this work is to extend a Single-Robot GSL to a Multi-Robot approach with information sharing and motion coordination among robots, aiming to improve efficiency and reducing the localization time.

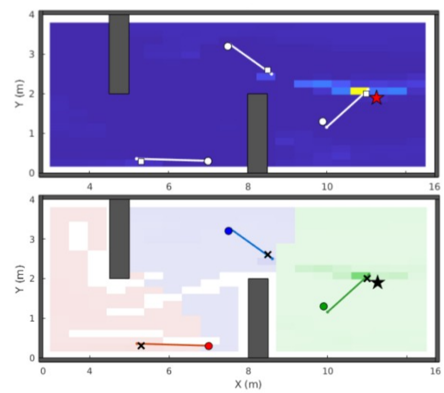
First it was decided that robots would operate under distributed control architecture, especially given its robustness and scalability in critical applications like GSL. It was also decided that they would share their belief maps and not the raw measurements, since being a PDF would work for both calibrated and uncalibrated sensors and better fits the chosen control architecture.

Following these two decisions, the following Finite State Machine (FSM) for MRS approach was considered, being the states colored in blue being the new ones compared to the Single-Robot framework:



Proposed Multi-Robot FSM version

First the robots estimate their own belief maps, then they share them with the rest of the team. The maps are then merged using Bayes' Theorem. After fusion, the space is distributed among the robots. Several region allocation strategies were considered -Voronoi partitioning, Lloyd's algorithm, and region growing-ranging from more geometry-based to more information-based criteria.

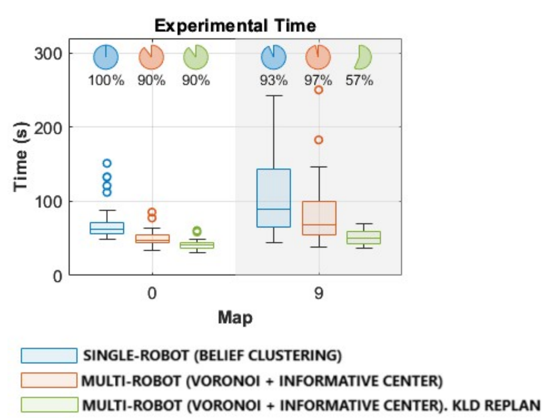


Lloyd's algorithm region allocation

A path planner was proposed: Informative Center. This planner allows the robot to target regions rich in information rather than individual cells, which could be misleading due to local maxima.

To reduce the overall team idle time, Kullback–Leibler divergence is used to quantify changes in the belief distribution, allowing the system to trigger replanning only when significant updates are detected.

Voronoi and Lloyd's clustering with Informative Center path planning generally perform well for both sensor types, except in complex scenarios with uncalibrated sensors.



Obtained results for 30 runs (calibrated sensors)