SS 2020-2021, ENS Lyon, DISAL-IP38 Project Summary

# Develop an effective Strategy for Gas Distribution Mapping and/or Source Localization using a Distributed Approach

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Chemical gas emissions can represent a severe threat to human and animal lives, as well as for the environment. It is essential to map such a gas distribution quickly and efficiently in order to monitor its progression and evacuate humans if needed. Furthermore, identifying the gas source is a necessity in the context of a leak, for maintenance crews (human or robot) to fix it. Most of the work on Gas Mapping and Source Localization use drones moving on a 2D plane, either with ground robots or constrained Unmanned Aerial Vehicles. But since gas dispersion is an inherently 3D phenomenon, a recent development in this field of research is to explore this third dimension. Additionally, some of the studies using ground robots exploit swarms of robots and produced interesting results, but this is yet to be done in 3D.

This work bases its navigation strategy on previous work, which uses clustering and entropy measurements to map a 3D gas distribution with a Crazyflie drone. The objective of this work was to use a multi-robot system for the task of gas localization and distribution mapping in 3D. The system was designed with ROS and used Webots for simulations.

The first step was to adapt the existing code to a distributed context, but keeping the main computation centralized. Six methods were designed for navigation, which could be classified in 3 categories: lawnmower, static space splitting, dynamic space splitting. Lawnmower is self-describing (based on a 3D Hilbert curve generator); static space clustering uses a geometric criterion to split the space a priori between the drones; dynamic space splitting uses a model (Gaussian Plume) which is fitted to the measurements during runtime and used as a base to split the space among the drones. A gas map of the environment is created using the Gaussian 3D Kernel DM+V/W algorithm.

Each method was tested using 2 drones, on 20 runs, with the real source position randomized. I used the clustering + entropy navigation strategy with only 1 drone as a control. The experiment takes place in a 7x2x0.5 $m^3$ area. After a run, the measurements were collected for post processing. It consists in fitting the results with the Gaussian Plume model. This provided a new estimation of the gas distribution as well as a source location estimation. If fitting the model led to a great improvement of the Root Mean Squared Error (from 10 to $10^{-7}$ for the best method), the source position was mostly wrong (more than 100m away). Nevertheless, the method which yield the best results regarding RMSE also gave an estimation less than 10m away from the real position 14 times out of 20. This method simply split the space along the wind direction, attributing to each drone a 1m wide corridor in which to move according to the clustering + entropy navigation strategy.
Even if this method provides good results, it reaches a coverage of 70%, indicating that we could employ our drones in a better way to increase the coverage of the space. Further studies should be done by scaling up the experiment space with the number of drones, in order to stay in a sparse measurement situation. Also, the source localization is to be improved. Finally, the dynamic strategies performed poorly. However, they can be improved by having a drone focus on areas were model and measurements differ.

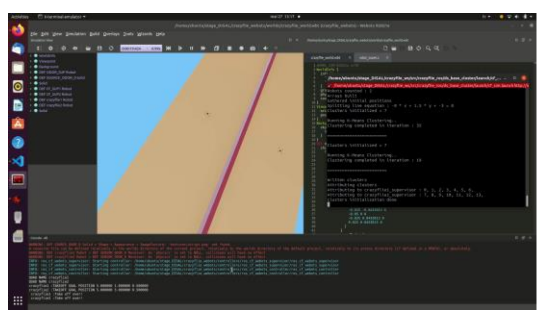

*Illustration of an ongoing simulation*