Multi-Robot Gas Distribution Mapping

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Being able to create a map of the gas distribution in a room can be useful in many situations such as during a gas leak. Using drones to build the gas distribution map could help assess the risks, facilitate rescue, and repair operations.
The goal of this project is to continue the research made at this laboratory and to develop a navigation algorithm for 3D gas distribution mapping using a multi-robot system instead of one robot. A variety of navigation methods will be implemented in this project to improve the performance and robustness of the algorithm. This work starts from a simple navigation algorithm to a more complex one using different coordination strategies each time: individual, cooperative, and collaborative. All the experiments will be on simulation using ROS and Webots. The two drones are CF2 Crazyflies V2.1 equipped with a sensor for odor measurement. All the measurements will be used to build a 3D gas concentration map using a 3D-Kernel DM+V/W algorithm.
The first navigation algorithm is the Levy flight method. This algorithm is a type of random walk which has less chance to come back to a previous position. The second navigation algorithm is an informative path planning algorithm (IPP) based on the Kulback Lieber Divergence strategy, and the goal is to use the information of the environment (odor measurement) to find the best trajectories for the drones.
Since there are two drones, they can communicate with each other. We implemented 3 coordination levels: individual (no sharing of information), cooperative (share their measurements) and collaborative (share their measurements and coordinate their movement). To make sure that the two drones don't collide, two collision avoidance algorithms were also implemented.
The simulation was run on an area of 7x2x0.5 m3. 5 runs were made for each method and the performance of the algorithm can be measured using the overall metrics M. A higher value gives a better map. Two baseline method were also implemented for comparison: Lawnmower motion and a method based on cluster and entropy implemented by a previous student.

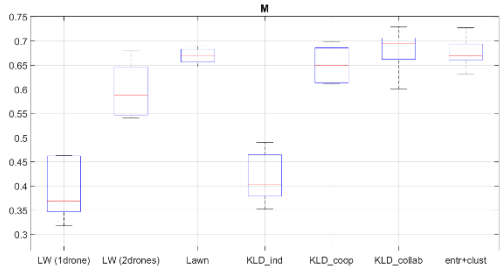

Figure 1: M metric for all the models

In figure 1 we observe that we get poor result for the Levy walk. This was expected since it is a random walk. Looking at the KLD algorithm a large improvement is observed when we increase the level of coordination, and it is therefore a field that can still be explored to improve the algorithm.

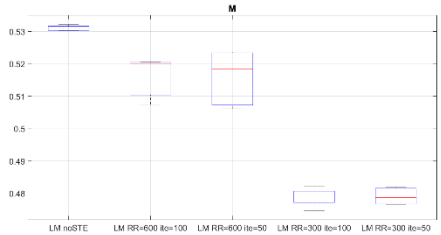

Figure 2: Comparison of the M metrics when adding the STE algorithm

Another idea was to add a source term estimation in the algorithm and to use it to find a better trajectory. Nevertheless, we observe that due to a too high computational power, this reduces the quality of the 3D gas map. To optimize this algorithm two variables were modified. The refresh rate of the algorithm and the number of iterations of the MCMC algorithm. We see that the refresh rate has a larger influence than the number of iterations.
All these results have been found on simulation and it must still be run on a real environment to see if we have similar results.