Adapting a Quadrotor for Odor Source Localization in a Realistic Environment

Valentin Kindschi

Professor : Alcherio Martinoli
Assistant(s) : Duarte Dias

At DISAL, Odor Source Localization (OSL) problems has been well studied in 2 dimensions. However, as a gas inherently evolves in 3 dimensions, using a quadrotor can help to have a more precise localization in space. Therefore, this project focuses first on implementing an existing odor sensor on a flying quadrotor. Then, different odor source setups were tested in a real flying arena to identify which was the closest to a real gas leak. Finally, an OSL algorithm was adapted to the quadrotor and tested both in simulation and in the real arena.

An Arduino was used to read the I2C signal of the sensor and transfer it via USB to the quadrotor's main computational unit (a Raspberry Pi). A node within the Robotic Operating System (ROS) framework was implemented in order to publish the odor measurements in the ROS system and make them usable by any other node running on the quadrotor's Raspberry Pi.

Using this sensor, a set of mapping experiments were conducted in a real arena with the quadrotor to identify repeatable setups that could be used to test an OSL algorithm. The experiments consisted of moving the quadrotor in predefined trajectories, layer by layer, from the bottom to the top of the arena. These trajectories were conducted with the quadrotor propellers turned ON and OFF to observe the propeller interference. The results were 3D maps showing ethanol concentrations at discrete points. These maps were interpolated to get the plume shape, as shown in Fig. 1. Three different setups were considered: an upward conic plume, a downward conic plume and a horizontal conic plume. A set of parameters were identified to modify the condition of the experiments: two external parameters - position of the pump, and wind strength generated by the fan – change the properties of the plume; two internal parameters - position of the sensor on the quadrotor and sensor frequency (kept constant at 1Hz) - change how the sensor measures the plume.

Finally, an OSL algorithm already developed at DISAL[i] was adapted for quadrotors and tested in both the simulation and real setups.

From the experiments, one can conclude that: (1) The shape of the plume is highly affected by the trajectory of the quadrotor due to propeller interference. Therefore, the quadrotor size needs to be scaled to the plume size very carefully. (2) The simulated plume does not take into account the saturation of the air with ethanol in the real setup, or the fact that the concentration of ethanol outside the plume is not zero, leading to simulation-to-reality gap of the algorithm performance. (3) The saturation of the air with ethanol in the real setup might not be realistic. (4) The sampling frequency of the odor sensor of 1Hz is too low for successful real experiments.

Future work could focus on increasing the sampling frequency of the odor sensor and investigate how exactly the quadrotor trajectory impacts the plume mapping. Doing outdoor experiments can also be considered to limit the impact of saturation. Finally, using a smaller quadrotor or a different aerial robot, which generates less perturbations could be investigated to reduce the scalability problem.

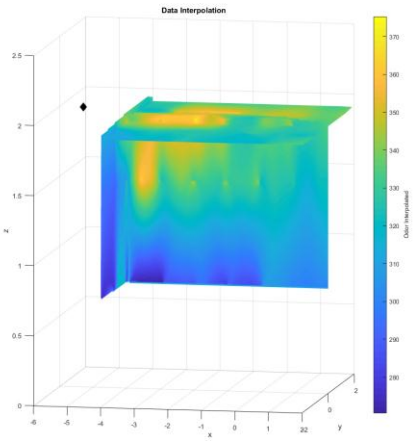

Figure 1: Horizontal conic plume interpolation (without perturbations)

[i] F. Rahbar, A. Marjovi, P. Kibleur, and A. Martinoli, "A 3-d bio-inspired odor source localization and its validation in realistic environmental conditions."