SS 2019-2020, SEL-EXC, DISAL-SP140 | Project Summary

Validation of High-Fidelity Simulator for Odor Sensing with a Quadrotor

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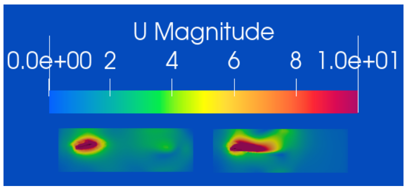
The problem of plume gas localization has been extensively studied recently, many solutions were found for 2D mapping by using wheeled robots equipped with a chemical sensor, but for the 3D case this task was more difficult. A nice solution to provide 3D coverage is to use nano-drones as they can reach any altitude and can rapidly move from a point to another compared to a blimp-based flying platform. However, the rotation of the drone's propellers perturbs the flow coming from the gas plume to be identified by the chemical sensor, therefore the robot could not perfectly recognize the direction of the gas. The problem is then to optimize the placement of the sensor.

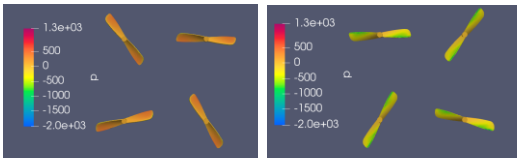
The wise solution would be then to simulate the flow around the drone in the presence of the gas plume, and identify the optimal placement of the chemical sensor on the drone where this fluid has maximum concentration compared to that of the air, this solution will be expensive in terms of time and space. Thus, we have simplified it to the one where only we simulate the air around the four propellers of the drone.

The CFD simulations was the wise mean to achieve this goal, we have used the open-source software OpenFoam which provides many solvers for these types of flows. The results provided from this software were then compared with experimental value of drone thrust in stationary regime, done by Bitcraze team, in order to validate our simulation.

The flow around is more complex to be laminar. Thereby, we have used the PIMPLE algorithm that is widely used for turbulent and unsteady flows. Thus, we get the following results for a moderate mesh:



Velocity field around the propellers



Pressure difference around the propellers

As we can observe the velocity field of the air under the drone is neglected, and the pressure under the propellers is higher than the pressure above them. By this mean we can deduct that the gas plume will have more interaction with the drone support in this region than any other one. Thereby, the optimal placement of the chemical is in this location on the drone.

To have more trust on our results provided by OpenFoam, we have calculated the thrust in the stationary regime on each propeller of the drone and then we compare the total value with the experimental one $0{,}385\ N$.

Propeller	**Thrust value $[N]$**
Cw1	0.091675
Cw2	0.090456
CCw1	0.090747
CCw2	0.090346
Drone	0.383224

As we can see above the relative error of our simulation compared to the real one is $5{,}65\%$, this error can be decreased by having a finer mesh.

In addition, if we want to view an animation of the simulation and get the velocity field at each moment, we can use *overPimpleDyMFoam.*