3D Odor Distribution Mapping in Simulation

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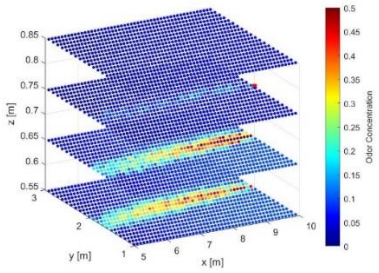
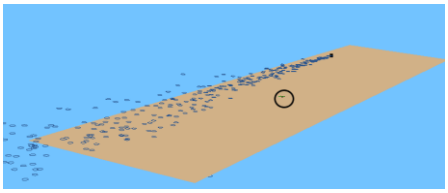
Odor distribution mapping involves obtaining the concentration of odor across the environment under inspection. It does not necessarily aim to determine the location of the source, even though it can be an added advantage. The mapping of odor faces many challenges: as we put an odor source in an environment, the plume obtained may be intermittent and unsteady and the involvement of mobile sensors further aggravates the issues by disturbing the plume. However, the greatest challenge is caused by the limited flight time. The drone, Crazyflie 2.0 used by us has a flight time of 4 minutes and 30 seconds only. This limits the region that can be covered and the resolution at which data can be obtained.



Plume of odor in the experimental setup (ground truth)

The flight time constraint is the main reason why the planning of motion such that maximum information is gathered is necessary. Informative Path Planning indicates the collection of algorithms that allow for planning while maximizing the amount of information gathered.

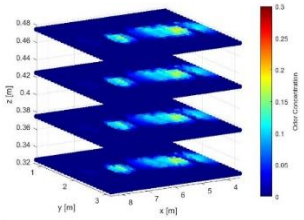
This project needs an online dynamic adaptive planning which means that the choice of the next position is made at each iteration based on the available knowledge. Thus, the IPP strategy is well suited for our problem statement. We have used IPP with Entropy and Kullback-Leibler Divergence metrics along with clusters for the dynamic planning.



Webots simulation

In this project, we aim to study the IPP strategy with clustering in which the environment to be mapped is decomposed into clusters of grid cells and then explored using the IPP strategy using KLD or entropy. Informative Path Planning involves a trade-off between exploration, that is gathering information about the environment, and exploitation, that is using the current information more efficiently. The clustering method biases the algorithm towards more of exploration. In the clustering method, we group the cells into a specified number of non-overlapping clusters. The decomposition of the environment is motivated by the locality property which states that two sets A and B which are sufficiently away from each other are almost independent. This means that more information can be gained by the robot by moving to several locations that are far away from each other.

The effect of adding clusters is then studied by analyzing the maps obtained by implementing the algorithm in the ROS based Webots simulation. Some experiments were also carried out at the DISAL facilities at EPFL to study the algorithms. It was seen that clustering helps improve the performance of IPP strategy because of more exploration.



Plume of odor obtained in simulation