Algorithms for Gas Source Localization using MOX Sensors

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In case of gas leaks, toxic chemical dispersion, or environmental emergencies, Gas Source Localization (GSL) helps to identify the gas source location. Using robots is a powerful tool since it reduces the risk for human and animal typically engaged in such missions. To tackle the problem of GSL, multiple strategies are available such as reactive plume tracking, plume model-based and mapping-based algorithm. In this project, we will focus on the map-based algorithm due to its modeless nature that enable it to be easily deployed in different scenarios.

Mapping-based GSL algorithm first build a map of the environment based on gas features and then estimate the gas source based by post-processing the map. Different agents like 2D/3D static sensor network and mobile robots are qualified candidates for data collection. The gas map can be built based on different features such as the instantaneous concentration, the mean concentration, the variance of the concentration or the frequency of gas hits, etc. As MOX sensors have a quite fast initial response (< 2 s) and a slow recovery time (~10 s), they will act as “leaky integrators” of gas concentration. Thus, methods based on instantaneous concentration may not the optimal solution under different scenarios. An algorithm developed by Schmuker et al. in 2016 offers an interesting alternative. The rising edges of the first derivative of the sensor response, which is called “bouts”, are extracted from the sensor reading in a fixed time window. The value of bouts indicates how many times we are hit by the gas particles and the frequency of the bouts is found correlated with the distance of the source: the closer the sensor is to the source, the higher is the bouts frequency. In this project, we focus on evaluating the performance of bouts algorithm in different scenarios. Static sensor networks in 2D and 3D have been used for simulating the data gather in the wind tunnel by using Webots. The gas map is built based on the bouts algorithm and mean concentration.

For all simulations, the data of the sensor network is recorded for five seconds with 10 Hz. Various environmental conditions have been explored: different wind speed, different source

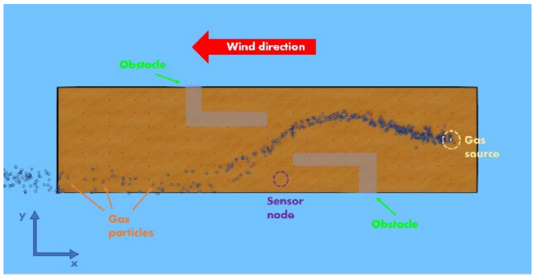

Figure 1 Simulation in Webots: gas plume in cluttered world

height and obstacle free vs cluttered environment. The source location is estimated as the position of the sensor that has the maximal mean gas concentration and the maximal number of bouts in a fixed measuring window. We have shown that satisfying results could be obtained using the bouts algorithm with a fine-tuning of its parameters. The bouts algorithm can outperform the other features, especially when it comes to 3D simulation with the 3D static sensor network. An example of the results comparing bouts algorithm and mean concentration in cluttered environment is shown below.

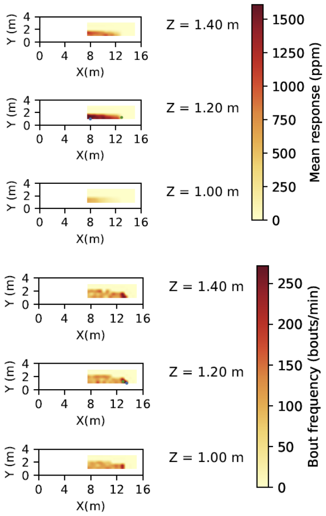

Figure 2 Source location estimation results by using mean concentration and bout frequency, with the green dot shows the true source location and blue dot shows the estimated one