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Particle Filter Algorithm for Odor source Localization in realistic environment

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Odor localization adapted for robotics is a good hope to replace dogs in tasks such as finding drugs, dangerous chemicals or explosives. Nonetheless, it faces many different challenges: the difficulties come not only from the sparse structure of the odor plume but also from the fact that most of the time, the map is unknown and so is the airflow. The researches were first concentrated on bio-inspired algorithm but recently, the probabilistic ones are more and more studied. The following report will address a probabilistic particle filter algorithm for odor source Localization, first implemented by Thomas Lochmatter on Khepera III. The major effort has been put into porting and adapting the existing algorithm on khepera IV. Then the performance has been evaluated in a realistic environment with an almost laminar flow.

The principle of this probabilistic algorithm is to discretized the search space (space of the source localization belief) into 1024 particles. The weights of the particles are updated at each time step as a function of the probability to find the source at the particle position, considering the previous robot observations. The speed of the robot is then updated depending on the most promising target over 10 discreet targets.

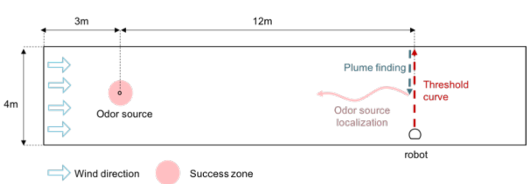

Figure 1. Graphical representation of the experiments setup (inside the wind tunnel)

Before running the probabilistic odor source localization algorithm, some initialization steps are due to find the plume for the first time and determine the algorithm parameters values (odor threshold and odor baseline). To do so, a first step has been implemented during which the robot cross the wind tunnel in the width while harvesting odor samples. The odor curve obtained is used to determine the threshold and the odor baseline. Then a plume finding step starts during which the robot goes back and forth in the crosswind direction until an odor concentration above the threshold is detected.

Once the algorithm has been implemented, it has been tested on a Khepera IV in a wind tunnel with a laminar wind's speed of 0.5 m/s (300 rpm). The robot is placed at 12m downwind the ethanol odor source. Each experiment is composed of 10 independent runs.

The results obtained showed insect-similar behaviors such as casting or spiraling. Nonetheless, the results were highly sensitive to the algorithm parameters choice. While a too low threshold leads to false plume detection, with a too high one, the plume is never found. The dependence on the threshold has been reduced by changing the method used to translate continuous odor concentration into binary hit observation. Instead of using a simple comparison between the odor concentration and the threshold, we added a baseline parameter. Thus, for a concentration between the odor baseline and the threshold, the hit is obtained with a linear probability.

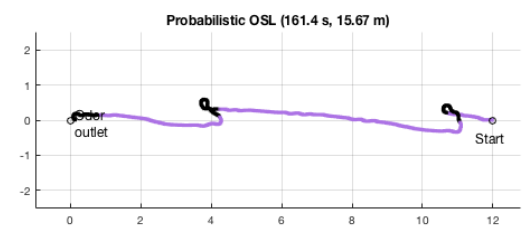

Figure 2. Example of a robot path obtained with probabilistic algorithm which exhibits spiraling behaviors

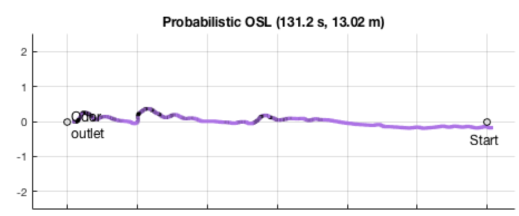

Figure 3. Exemple of a robot path obtained with probabilistic algorithm which exhibits casting behaviors

A way to improve the results and especially the threshold impact may potentially be to change the previous hit probability for a less linear way, or even abandon the binary observation. Nonetheless, next steps would be to test the algorithm robustness in more complex wind condition.