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Performance evaluation of bio-inspired algorithms in odor source localization

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The odor source localization problem is currently taking an important place in the field of robotics and embedded systems. Its possible applications in real environments are vast and require to bring together many knowledges. A way to answer the problem is to consider how living beings deal with it to find food or track sexual pheromones up to their mates. Such studies were led by biologists over many insects and animals. In particular, moths gave birth to several algorithms combining the main behaviors that were identified.

Illustration: A KheperaIV running an algorithm in the wind tunnel. The source is located above the white sheet of paper in the back, 10 cm above the ground. The wind comes from the background wall.

As the odor source localization problem is very complex, it is conventionally split in three parts: plume finding, plume traversing and source declaration. The present project focuses on the second part – i.e. from an odor cue, move up to the source until a minimum distance is reached and success can be declared thanks to an external input.

In total, four algorithms were tested in this project. Three of them are moth-inspired, namely casting, surge-cast and surge-spiral algorithms. They were tested in a wind tunnel while changing the wind speed and release rate of a pump, spreading ethanol or acetone, in order to affect environmental conditions. A forth algorithm called Lévy-taxis was prototyped in Matlab, then implemented in Webots and finally tested in the same wind tunnel. Embedded systems in the wind tunnel involved KheperaIV robots as searching agents and a global positioning system called SwisTrack for localization purpose. As the determination of being in or out of the plume takes an important place in moth-inspired algorithms, a way to determine a threshold was developed based on the advective-diffusive equations.

It was shown that algorithms perform well for wind speeds between 0.5 m/s to 1.5 m/s yielding average distances overhead between 1.1 and 1.5. For lower wind speed of 0.1 m/s, moth-inspired algorithms lose in efficiency, reaching average distances overhead of above 2.0 and dramatically low success rates often below 40 %. The effect of the release rate variations affects differently the algorithms according to the wind speed in presence. The surge-spiral algorithm was found more robust than the two other moth-inspired algorithms. Lévy-taxis succeeded 100 % in all setups tested with average distances overhead only slightly higher than these obtained with surge-spiral algorithm, i.e. around 1.6.