Particle Filters for Gas Source Localization in Cluttered Environments

Jonathan Henry

Professor : Alcherio Martinoli
Assistant(s) : Wanting Jin, Chiara Ercolani

Gas source localization is traditionally performed by humans or animals, which put their life and health at risk. Indeed, gas can be toxic or explosive in nature and sending humans or animals into this environment is hazardous. Mobile robotics has made incredible progress in recent years. Robots are now able to navigate reliably multiple types of terrain, navigation accuracy drastically improved as well as sensors capability and accuracy. All these improvements have led to an increase in interest in Mobile Robotic Olfaction (MRO).

Due to the nature of gases, reliable experimental setups are complex to set up: gas dispersion is dependent on many factors, making it almost impossible to perform the same experiment multiple times. In addition to that, gas sensing is noisy. Therefore, MRO algorithm needs to be probabilistic to precisely locate the gas source.

Multiple algorithms were proposed for MRO, using different types of data to track the source. This is focused on a grid algorithm as a basis for a new algorithm using a particle filter for the source localization. The grid algorithm works by creating a grid over the whole environment and assigning the same weight for each cell at first. The weight of the cells is then updated with the gas and wind information measured by the robot: in case of gas, the cells upwind will have a higher weight and the ones downwind will have a lower weight. The robot moves from cell to cell, choosing its next goal by evaluating which cell should give the most information for the algorithm. The source is estimated to be found the weight of a cell is higher than a chosen threshold.

The particle filter uses a set of particles to estimate the source position. These particles each have a weight and a position. Only the weight is modified, and the particles “move” by resampling only: the irrelevant particles are destroyed and replaced by new particles using the wind information. When these particles are concentrated enough, an estimation of the source position is calculated using the weighted average of the position of all particles.

The new algorithm uses the particle filter algorithm to estimate the gas source position and the grid algorithm to move in a meaningful way. The combination of the two algorithms allowed us to obtain a more accurate source position declaration at the expense of a relatively lower success rate. As the particle filter is stricter with the termination condition, the failure rate is a bit higher than the grid algorithm. However, the new algorithm seems to be more robust in more adversarial situations.

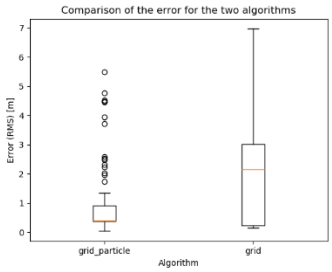

Figure 1: Boxplot showing the performance of the grid-particle algorithm and the grid algorithm.

The experiments to try the algorithm were carried out using Gaden, a gas dispersion framework developed for MRO. Gaden uses ROS to communicate with the robot and simulate the on-board sensors. This software supports the creation of new environments as well as multiples gas source. A guide to the creation of new environments, from the CAD to the simulation, was created as part of the project as well.

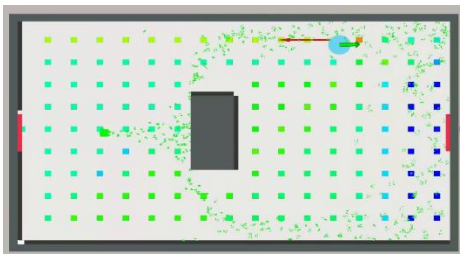

Figure 2: Gaden interface with the grid algorithm