Optimal Sensing Strategy Using Spatially Averaged Advection-Diffusion Parameter Estimation

Andrew White[1], Jongeun Choi[1*], and L. Guy Raguin[1, 2]
[1]*Department of Mechanical Engineering*, [2]*Department of Radiology*
[*]*jchoi@egr.msu.edu*

Abstract

Many physical transport phenomena exist that are governed by advection-diffusion processes. Examples include, but are certainly not limited to, algae blooms and chemical plumes. Due to the harmful nature of these phenomena, researchers have been developing methods to track the source [1, 2]. The motivation in this research effort is to develop an algorithm that estimates the parameters of an advection-diffusion process using mobile sensing agents.

We consider a surveillance region undergoing an advection-diffusion process with unknown parameters. A team of nonholonomic sensing agents is coordinated in a formation to collect noisy concentration measurements from the surveillance region. Nonlinear least squares is applied to the collected measurements to estimate the parameters of the advection-diffusion process. To judge the quality of the measurements, the Fisher Information Matrix is computed. Applying the Cramer-Rao theorem, mobile robots are coordinated to maximize the determinant of the Fisher Information Matrix to decrease the lower bound of the covariance of the estimated parameters. As a result, the robots are driven to the source location of the advection-diffusion process.

In Fig. 1-2, we consider a continuous source, while in Fig. 3 we consider the response to an impulse function.

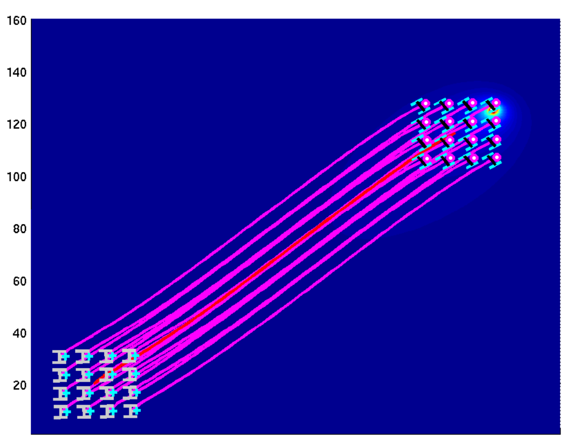

Figure 1. Sensing agents tracking the continuous source starting from $(x_0, y_0) = (20, 20)$.

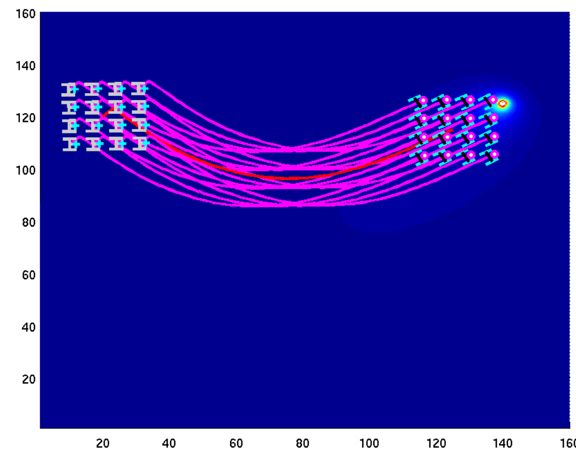

Figure 2. Sensing agents tracking the continuous source starting from $(x_0, y_0) = (20, 120)$.

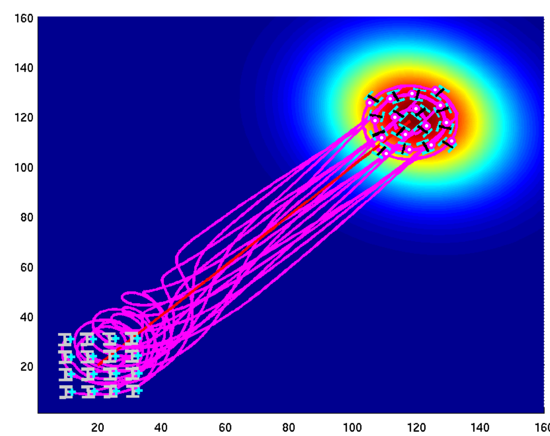

Figure 3. Sensing agents tracking the impulse response starting from $(x_0, y_0) = (20, 20)$.

References

[1] A. Dhariwal, G.S. Sukhatme, and A.A.G. Requicha, “Bacterium-inspired robots for environmental monitoring”, *Proceedings of the IEEE International Conference on Roboics and Automation*, 2004.

[2] H. Ishida, Y. Kagawa, T. Nakamoto, and T. Moriizumi, “Odor-source localization in the clean room by an autonomous mobile sensing system”, *Sensors and Actuators B33*, 1996, pp. 115-121.