Importance Sampling With Stochastic Particle Flow and Diffusion Optimization: Supporting Results

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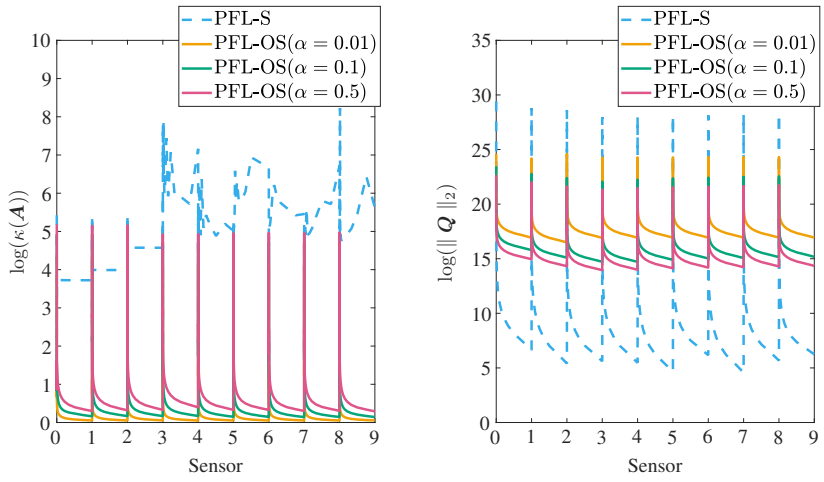
This manuscript provides derivations and further simulation results for the letter, "Importance Sampling With Stochastic Particle Flow" by the same authors.

1 Additional Numerical Analysis

Fig. 1 shows the condition number of the Jacobian matrix $\boldsymbol{A}$ and the norm of the diffusion matrix $\boldsymbol{Q}$ for the stochastic particle flows (PFLs) considered in [1, Sec. IV]. Different values of α are compared. The time resolution is set to $(1.5, 1\mathrm{e}-5)$. For efficient particle transition and small process noise, $\kappa(\boldsymbol{A})$ and $\|\boldsymbol{Q}\|$ have to be small. However, there is an inherent traded off between these two parameters [2]. As can be seen in Fig. 1, compared to importance sampling (IS) with Gromov's flow, the proposed IS with diffusion optimization can significantly reduce the condition number while at the same time avoid large process noise peaks. A smaller value of α results in a stronger reduction of the condition number (i.e., a stronger effort to reduce stiffness), which, in turn, leads to an increased process noise variance (i.e., a larger norm of $\boldsymbol{Q}$). Since a too-large process noise variance also reduces the accuracy of the flow, carefull selection of α is crucial for the success of the proposed method.



(a) (b)

Figure 1: Log condition number of the Jacobian matrix (a) and log 2-norm of the diffusion matrix (b) of the drift term of different stochastic particle flows. The x-axis of the plot consists of a concatenation of pseudotimes across different sensors. The numerical integration parameters $(\beta, \Delta_1) = (1.5, 1\mathrm{e}{-5})$ were used across different sensor update steps.

References

[1] W. Zhang, M. J. Khojasteh, N. A. Atanasov, and F. Meyer, "Importance sampling with stochastic particle flow and diffusion optimization: Supporting results," *IEEE Signal Process. Lett.*, 2024, submitted.

[2] L. Dai and F. Daum, "On the design of stochastic particle flow filters," *IEEE Trans. Aerosp. Electron. Syst.*, vol. 59, no. 3, pp. 2439–2450, 2023.