Abstracts SIAM CSE 2021 - 2021 SIAM Conference
on Computational Science and Engineering
Forth Worth (Texas, USA), March 1-5 2021

Bayesian Inference for Inverse Scattering Problems with Topological Priors

Ana Carpio, Universidad Complutense de Madrid

Sergei Iakunin, Basque Center for Applied Mathematics, Spain

Georg Stadler, Courant Institute of Mathematical Sciences, NYU, U.S.

We propose a Bayesian inference framework to estimate uncertainties in inverse scattering problems [1]. Given the observed data, the forward model and their uncertainties, we find the posterior distribution over a finite parameter field representing the objects. To construct the prior distribution we use a topological sensitivity analysis. We demonstrate the approach on the Bayesian solution of 2D inverse problems in light and acoustic holography with synthetic data [2, 3, 4, 5]. Statistical information on objects such as their center location, diameter size, orientation, as well as material properties, are extracted by sampling the posterior distribution. Assuming the number of objects known, comparison of the results obtained by Markov Chain Monte Carlo sampling and by sampling a Gaussian distribution found by linearization about the maximum a posteriori estimate show reasonable agreement. The latter procedure has low computational cost, which makes it an interesting tool for uncertainty studies in 3D. However, MCMC sampling provides a more complete picture of the posterior distribution and yields multi-modal posterior distributions for problems with larger measurement noise. When the number of objects is unknown, we devise a stochastic model selection framework.

References

[1] A. Carpio, S. Iakunin, G. Stadler, Bayesian approach to inverse scattering with topological priors, Inverse Problems 36, 105001, 2020

[2] A. Carpio, T.G. Dimiduk, F. Le Louer, M.L. Rapun, When topological derivatives met regularized Gauss-Newton iterations in holograhic 3D imaging, Journal of Computational Physics 388, 224-251, 2019

[3] A. Carpio, T.G. Dimiduk, V. Selgas, P. Vidal, Optimization methods for in-line holography, SIAM Journal on Imaging Sciences 11(2), 923-956, 2018

[4] A. Carpio, T.G. Dimiduk, M.L. Rapun, V. Selgas, Noninvasive imaging of three-dimensional micro and nanostructures by topological methods, SIAM Journal on Imaging Sciences 9(3), 1324-1354, 2016

[5] A. Carpio, M.L. Rapun, Hybrid topological derivative and gradient-based methods for electrical impedance tomography, Inverse Problems 28(9), 095010, 2012