Bayesian shape inversion in acoustic and electromagnetic scattering

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We consider the problem of recovering the shape of a scatterer from measurements of its scattered field upon acoustic or electromagnetic excitation. To quantify the uncertainty in the reconstructed shape, we cast the inverse problem in a Bayesian setting. The physics is described by the Helmholtz equation (for acoustic scattering) or time-harmonic Maxwell equations (for electromagnetic scattering).

We study the well-posedness of the Bayesian inverse problem in a frequency-explicit way. We discuss numerical methods to sample efficiently from the posterior, by combining sequential Monte Carlo sampling [1] with a finite element discretization on a reference configuration to avoid remeshing [2]. Numerical results for the Helmholtz equation illustrate the effectiveness of our approach as well as the effect of the frequency on the sampled posterior.

[1] Beskos, Alexandros, Jasra, Ajay, Muzaffer, Ege A., & Stuart, Andrew M. (2015). Sequential Monte Carlo methods for Bayesian elliptic inverse problems. Statistics and Computing, 25, 727-737.

[2] Xiu, Dongbin, & Tartakovsky, Daniel M. (2006). Numerical methods for differential equations in random domains. SIAM Journal on Scientific Computing, 28(3), 1167-1185.