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Stochastic reduced order models for inverse problems in the presence of uncertainty

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This work presents a novel approach for inverse problems in the presence of uncertainty using stochastic reduced order models (SROMs). Given the statistics of an uncertain observed quantity, unknown system parameters are estimated probabilistically through the solution of a stochastic optimization problem. The point of departure and crux of the proposed framework is the representation of a random quantity using a SROM – an optimal discrete approximation to a continuous random element that permits efficient and non-intrusive stochastic computations. Characterizing the uncertainties with SROMs transforms the stochastic inverse problem into a deterministic optimization problem in a larger dimensional space. The non-intrusive nature of SROMs facilitates efficient gradient computations for random fields using an Adjoint Method approach. Furthermore, the method is naturally extended to handle multiple sources of uncertainty in cases where measurement data, system parameters, and boundary conditions are all considered random.

The method is applied to the inverse identification of random material parameters in elastodynamics. We demonstrate the ability to efficiently recover a random field given displacement statistics as input data. We also show that the approach remains effective for the case where the loading in the problem is also random.