The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

GREEDY SENSOR PLACEMENT FOR BAYESIAN INVERSE PROBLEMS VIA MODEL ORDER REDUCTION

Nicole Aretz[1], Nada Cvetkovic[2a], Francesco Silva[2b] and Karen Veroy[2c]

[1] University of Texas, Austin, TX 78712-1229, USA, nicole.aretz@austin.utexas.edu
[2] Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands
[a] n.cvetkovic@tue.nl, [b] f.a.b.silva@tue.nl, [c] k.p.veroy@tue.nl

Key Words: *Uncertainty Quantification, Sensor Placement, Optimal Experimental Design, Inverse Problems, Bayesian Inference*

Models of physical processes often depend on parameters, such as material properties or source terms, that are only known with some uncertainty. Measurement data can be used to estimate these parameters and thereby improve the model's credibility. When measurements become expensive, it is important to choose the most informative data. This task becomes even more challenging when the model configurations vary and the data noise is correlated.

In this work, we consider optimal sensor placement for hyper-parameterized Bayesian inverse problems, where the hyper-parameter characterizes nonlinear flexibilities in the forward model, and is considered for a range of possible values. This model variability needs to be taken into account for the experimental design to guarantee that the Bayesian inverse solution is uniformly informative. In this work we link the numerical stability of the maximum a posterior point and A-optimal experimental design to an observability coefficient that directly describes the influence of the chosen sensors. We propose an algorithm that iteratively chooses the sensor locations to improve this coefficient and thereby decrease the eigenvalues of the posterior covariance matrix. This algorithm exploits the structure of the solution manifold in the hyper-parameter domain via a reduced basis surrogate solution for computational efficiency. The algorithms are suitable for correlated noise models as well as large-scale forward models, achieving computational efficiency through model order reduction.

Acknowledgments: This work was supported by the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (ERC Consolidator Grant agreement No. 818473).

REFERENCES

[1] Aretz-Nellesen, N., Chen, P., Grepl, M. A., & Veroy, K. (2019). A Sequential Sensor Selection Strategy for Hyper-Parameterized Linear Bayesian Inverse Problems. In *ENUMATH* (pp. 489-497).

[2] Ucinski, D. (2004). *Optimal measurement methods for distributed parameter system identification*. CRC press.

[3] Stuart, A. M. (2010). Inverse problems: a Bayesian perspective. *Acta numerica*, *19*, 451-559.