Ph.D. offer in applied mathematics:
Adaptive sampling strategy for nonlinear dimension reduction in uncertainty quantification.

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Job environnements The PhD thesis will start in Fall 2022 at the Université Grenoble Alpes in the Inria-AIRSEA team located in Grenoble (France). This work is part of an ongoing collaboration with Monash University and MIT[1].

Project description Computational models from a wide range of fields, such as physics, biology, and finance, involve large numbers of uncertain input parameters. Quantifying the uncertainty caused by these random parameters is essential to improve the reliability of the models. Identifying which input parameters are the most relevant permits significant computational savings by putting the numerical effort onto the relevant parameters [1,2]. This dimension reduction step can be efficiently done using gradients of the model, if the latter are available [3,4].

Nonlinear dimension reduction consists in seeking a nonlinear manifold in the parameter space which best captures the model response. Formally, this consists in approximating the model by *composition of functions*, an approximation format which is now commonly encountered in machine learning. Exploiting the gradients of the model has recently emerged as a promising line of research for the efficient construction of such composed approximation [5].

In this Ph.D. project, we aim at developing optimal adaptive sampling strategies in order to determine where to evaluate the model and its gradients to get the best possible composed approximation. A thorough theoretical analysis and a numerical validation on various benchmarks of increasing complexity will guide the elaboration of the technique.

Candidate profile This PhD work is at the crossroad between numerical analysis, statistics and machine learning. Candidates must have good knowledge for at least one of these domains and the motivation to quickly acquire the missing complementary skills. This research work will involve both theoretical developments and practical implementations. Candidates should have demonstrable experience and skill in some of the following topics : scientific creativity, autonomy, writing abilities, oral communication skills (English and/or French), and taste for teamwork.

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How to apply The candidates should send a CV, statement of interest and letters of recommendation to Olivier Zahm (`olivier.zahm@inria.fr`) and Clémentine Prieur (`clementine.prieur@univ-grenoble-alpes.fr`)

References

[1] Saltelli et al. *Global sensitivity analysis: the primer.* John Wiley & Sons, 2008.

[2] Da Veiga et al. *Basics and Trends in Sensitivity Analysis: Theory and Practice in R.* SIAM, 2021.

[3] Constantine, Dow, Wang. *Active subspace methods in theory and practice: applications to kriging surfaces.* SIAM Journal on Scientific Computing (2014).

[4] Zahm, Constantine, Prieur and Marzouk: *Gradient-based dimension reduction of multivariate vector-valued functions.* SIAM Journal on Scientific Computing (2020).

[5] Bigoni, Marzouk, Prieur and Zahm: *Nonlinear dimension reduction for surrogate modeling using gradient information.* arXiv 2021.