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Probabilistic learning on manifolds for the small-data challenge in Uncertainty Quantification

Christian Soize

Université Paris-Est Marne-la-Vallée, Laboratoire MSME UMR 8208, France
christian.soize@u-pem.fr

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ABSTRACT

This work is devoted to a novel approach concerning a probabilistic learning on manifolds [1] from small datasets with applications to Uncertainty Quantification. This new tool of the computational statistics can be viewed as a useful method in scientific machine learning based on the probability theory. We first explain the concept/method of this probabilistic learning on manifolds by discussing a challenging problem of nonconvex optimization under uncertainties (OUU). We will then present the mathematical formulation and the main steps of the method based on the construction of a diffusion-maps basis and the projection on it of a nonlinear Itô stochastic differential equation. After having presented two simple illustrations, fours applications will be presented:

1. Optimization under uncertainties using a limited number of function evaluations [2].
2. Design optimization under uncertainties of a mesoscale implant in biological tissues using probabilistic learning [3].
3. Enhancing model predictability for a scramjet using probabilistic learning on manifolds [4].
4. Probabilistic learning on manifolds for nonparametric probabilistic approach of model-form uncertainties in nonlinear computational mechanics [5].

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