Gaussian process multi-fidelity surrogate models for time-dependent outputs

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Abstract:

Kriging surrogate modelling techniques have proven their efficiency as a substitution tool for expensive low dimension input/output calculation codes. Subsequently co-Kriging techniques were introduced to allow the analysis of hierarchical codes with different fidelities, but in the context of scalar input/output[1], [2]. Some recent advances made possible the study of temporal output codes [3]. For the same physical system there are different codes with hierarchical fidelities, where a higher fidelity implies a higher cost.

We focuse on multi-fidelity hierachical computer codes, i.e. codes modelling the same phenomenon, but which can be hierarchically sorted according to their accuracy and numerical cost. To improove the high-fidelity metamodel, we collect information on low-fidelity codes. We extend the multi-fidelity CoKriging method [2] when the output is a time series. Instead of reducing the dimension of the output by principal component analysis, the proposed approach uses a tensorized structure of the covariance function for the highest version of the code.

A first attempt was to try to reduce the size of the outputs. However, the problems associated with the adapted base mean that theoretical considerations are lacking. Moreover, the estimation of outputs is doubly flawed. First, the base is created from a small number of outputs and secondly the base is not optimal for the lowest fidelities. This is why we add, in a second time, the temporal structure of the covariance [3] to the reduction of the dimension for the low-fidelity codes.

Finally, we present an example on which we will compare the proposed methods.

References

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[2] Loic Le Gratiet and Josselin Garnier. Recursive co-kriging model for design of computer experiments with multiple levels of fidelity. 4:365–386, 01 2014.

[3] Guillaume Perrin. Adaptive calibration of a computer code with time-series output. *Reliability Engineering & System Safety*, 196:106728, 2020.

Short biography – Baptiste Kerleguer got a Master's Degree in applied mathematics from Ecole Normale Suprieure Paris-Saclay. His thesis, funded by the CEA DAM, focuses on surrogate models at functional input and output for the analysis and quantification of uncertainties in complex models.