Bayesian calibration of two nested phenomena

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Abstract:

Simulation has an increasing role for the conception, the optimization and the risk analysis of complex systems. Computer codes modeling the complex system are thus introduced. However the computational cost of a single run of the computer code can be high. Surrogate models are therefore introduced. Among the surrogate methods Kriging provides a probabilistic framework and enables to build a predictor of the studied phenomenon (the output of the costly computer code) and to estimate the uncertainty of this prediction ([5], [6], [3], [1], [2]). In Kriging the phenomenon is considered as a realization of a Gaussian process. The computer model is defined by its design inputs and its input parameters. The input parameters are supposed to be independent of the design inputs and have to be calibrated for the computer model to be predictive. In a Bayesian framework ([4]) Kriging provides a formalism for calibration and prediction, that means the computation of the posterior distributions of the input parameters and of the Gaussian process given the observations of the phenomenon([5], [6]).

In this work the aim is to analyze the behavior of a complex phenomenon which can be decomposed in two nested phenomena, that means that the output of the first phenomenon is an input of the second phenomenon. In this framework our goal is to calibrate the parameters of the two phenomena and to build a predictor of the nested phenomenon. The available information can be observations of the phenomena 1, 2 or nested.

First we propose methods to calibrate the input parameters and build a predictor of a nested phenomenon. In particular these methods enable to take all the information into account, partial information in particular, that means observations of the phenomena 1 or 2 alone. They also integrate all the sources of uncertainty.

Second, since the choice of the observations impacts the posterior distributions of the parameters and the phenomenon, the choice of the observation points is studied and sequential designs specific for the case of a nested phenomenon are proposed. These criterion-based designs enable to improve the performance of calibration and prediction while optimizing the computational budget by exploiting the nested structure of the studied phenomenon.

The proposed methods are then applied to examples.

References

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Short biography – Graduate from Ecole Centrale de Lyon in 2010, I have worked for 5 years as engineer in building energy performance.
In 2014-2015 I have studied in M2 ISIFAR at Université Paris Diderot Paris 7 and I have done an internship in applied mathematics at CEA. Then I have pursued with a PhD in bayesian calibration of nested computer models, which began in November 2015.