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Editorial of the special issue: Computer Experiments, Uncertainty and Sensitivity Analysis

Titre: Éditorial du numéro spécial : expériences numériques, analyse d'incertitude et de sensibilité

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Computer simulation has gained more and more place during the last decades in daily practice of scientists and practitioners with domains of application covering a great number of disciplines: civil, mechanical, hydraulic and environmental engineering, measurement science, agronomy, finance, chemistry, medicine ... actually, most of the technical and scientific disciplines. This diffusion of computer simulation has been made possible by the availability of more and more powerful (and cheap) computers since the 80's and the 90's. It has deeply changed the way of working of professionals in industry and academia, giving them the possibility to realize *in silico* experiments that prove difficult (or impossible) to be made in the real world, for instance because of costs or safety issues.

On the other hand, questions are often raised about the credibility of the results and the robustness of the decisions based on these results. The assessment of uncertainties associated with the outputs of computer simulations appears nowadays as a more and more essential part of studies based on computer modelling and simulation. It involves the strictly related and fundamental questions of the effective and parsimonious design of computer experiments and sensitivity analysis. Based on well-known foundations (e.g. Monte Carlo sampling, design of experiments theory, Gaussian process regression, Wiener's polynomial chaos expansion, Hoeffding's decomposition ...), the methods and tools that are used today for computer experiments have been and remain a topic of active research, with a fruitful cooperation between industry & business and academia. In France, large working groups testify on the dynamism and the momentum of the community created around these activities. Such groups include the CNRS GdR MASCOT-NUM (http://www.gdr-mascotnum.fr) or the network MEXICO (http://reseau-mexico.fr/) supported by INRA or the thematic group *Reliability & Uncertainty* of the French Statistical Society (SFdS), as well as many funded research projects and consortia.

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Statisticians have been at the forefront of the recent theoretical and applied progress on computer experiments, as well as on uncertainty and sensitivity analyses. Indeed, simulation-based experimentation requires refined statistical methods in order to infer properly detailed model properties based on relatively small samples of simulation data.

The present special issue is the opportunity to illustrate the rich interactions between statistics and computer experimentation. It is made of five articles, covering a quite wide variety of topics, in terms of methods and applications, so that it can be interesting for a large public of researchers and practitioners.

The article of Luc Pronzato, "*Minimax and maximin space-filling designs: some properties and methods for construction*", tackles the crucial topic of the optimal designs of computer experiments and gives a very complete overview of properties and limitations of maximin and minimax designs, with a particular focus on the difficult question of the dimension of the input space. Firmly rooted in a extremely wide theoretical and methodological review, it gives precious indications to build designs with good performances when optimality cannot be attained, because of the complexity of the problem.

In the article "*A repulsion-based method for the definition and the enrichment of optimised space filling designs in constrained input spaces*", Guillaume Perrin and Claire Cannamela also deal with the question of optimal space-filling designs and proposes a method adapted to the case in which the input space is not - or cannot be transformed through a bijection into - a hypercube. In particular, a generalization of optimised LHS is proposed for the case when the inputs belong to a bounded convex domain (e.g. a simplex or an hypersphere).

Then, the next two articles are focused on global sensitivity analysis.

Julien Sainte-Marie, Gautier Viaud and Paul-Henry Cournède ("*Indices de Sobol généralisés aux variables dépendantes : tests de performance de l'algorithme HOGS couplé à plusieurs estimateurs paramétriques*") consider the problem of global sensititivity analysis for dependent inputs and in particular the algorithm HOGS (Hierarchically Orthogonal Gram-Schmidt) for the estimation of the generalized Sobol' indices. Different configurations of the algorithm and different parametric estimation techniques are investigated and tested on several examples, including a computer model describing plant growth.

The article of Laurent Gilquin, Thomas Capelle, Élise Arnaud and Clémentine Prieur, "*Sensitivity analysis and optimisation of a land use and transport integrated model*", is concerned with an interesting application of sensitivity analysis, here used as one of the two steps (together with iterative optimisation) of the calibration of a complex model, describing interactions between land use and transportation at a regional scale (family of the so-called LUTI models). To the best of our knowledge, the applications of these methods to quantitative models for sustainable planning of cities and territories are not very numerous, so far, and this article will hopefully help in creating links with this growing community.

The article "*Surrogate model based sequential sampling estimation of conformance probability for computationally expensive systems: application to fire safety science*" of Séverine Demeyer, Nicolas Fischer and Damien Marquis closes this special issue. It presents a methodological framework to estimate a low probability for the output of a computer model to exceed a fixed

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threshold, combining sequential design of experiments and multi-fidelity metamodelling. The methodology is applied to a fire-safety engineering problem, i.e. the evaluation of the non-conformity of a smoke control device.

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We wish you enjoyable reading.

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