PhD position in applied mathematics

Title : Spectral methods and non-stationary kernels in computer experiments

Domain : Applied mathematics.

PhD advisor : R. Le Riche (leriche@emse.fr).
Co-advisor : X. Bay (bay@emse.fr), O. Roustant (roustant@emse.fr).

Application deadline : 31st of May
PhD starts : October 2010
Location : Ecole Nationale Supérieure des Mines de Saint-Etienne (National Institut of Science and Technology at Saint-Etienne), France.
Salary : 1300 to 1600 euros / month

Scientific context
Computer experiments is addressing the study of costly industrial computer codes such as car crash-test simulators, neutronic softwares, etc. (see [Fang, Li, Sudjianto 2006], or [Santner, Williams, Notz, 2003]). Through the DICE project (www.dice-consortium.fr), the CROCUS team (http://3mi.emse.fr/) has developed successful methods for metamodeling. For instance, it has risen the interest of unusual spectral methods: in [Picheny, 2009], a close connection has been made between the design of experiments under a constant budget assumption and the spectral representation of Hilbert-Schmidt operators. In addition, promising results have been obtained with non-stationary kernels which allow taking into account some problem specificities such as symmetric response surfaces ([Ginsbourger, 2009]). Nevertheless, difficulties remain when modeling irregular response surfaces (a first solution is the treed Gaussian processes [Gramacy, 2007]).

Objectives
The objectives of this PhD are to extend the methodologies of response surfaces using spectral methods and non-stationary kernels. More precisely, two directions are going to be explored:

- The spectral representation of Hilbert-Schmidt operators will be used to i) find optimal designs suited for kriging metamodeling, ii) build Gaussian process models in high dimensions.
- The systematic analysis of non-stationary kernels will be performed, allowing to add application related knowledge to the kernel (e.g., symmetry), and as a consequence address a wider range of industrial applications.

The developed methods will be applied to problems related to fluids mechanics.

Bibliography

- Fang, K.-T., Li R., and Sudjianto A. (2006). *Design and Modeling for Computer Experiments*. Chapman & Hall.
- Ginsbourger, D. (2009), *Multiples métamodèles pour l'approximation et l'optimisation de fonctions numériques multivariables*, Thèse de doctorat en mathématiques appliquées délivrée par l'Ecole Nationale Supérieure des Mines de Saint-Etienne.
- Robert B. Gramacy (2007). tgp: An R package for Bayesian nonstationary, semiparametric nonlinear regression and design by treed gaussian process models. *Journal of Statistical*

Software, 19(9).

- Picheny V. (2009), *Propagation d'incertitudes dans les grands codes de calcul modélisés par surfaces de réponses,* Thèse de doctorat en co-tutelle avec l'université de Floride.
- Santner, T., Williams B., and Notz W. (2003). *The Design and Analysis of Computer Experiments*. Springer-Verlag

Anticipated added value

- Methodological improvements in the design and modeling of computer experiments.

Candidate profile

Applied mathematics: probability, functional analysis.
Programming skills (R).
Interest for computer experiments and their applications (fluids).