Post-doctoral position at IFP Energies nouvelles:
Exploration of some new challenges encountered in uncertainty quantification: (a) computer experiments with functional inputs, outputs and associated metamodels, (b) global sensitivity analysis with dependent inputs. Applications in energy domain (petroleum reservoir, wind turbine, drilling riser,...).

Duration: 1 year

Location: Rueil-Malmaison

Context:
The post-doctoral position is proposed in the framework of a transverse activity project dealing with a large panel of industrial problems where functional or dependent data (real or simulated) are common and natural. The following are some practical examples where uncertain dependent or/and functional inputs appear spontaneously.

In reservoir engineering, the geological parameters are known partially and this uncertainty propagates on the prediction of future production.

The efficient design of floating wind turbine to withstand the marine environment is of great importance to ensure the development of this technology. Wind and wave are by nature uncertain space-time dependent variables, thus their space-time impact on floating wind turbine is uncertain. The same phenomena is encountered in the design of drilling risers submitted to uncertain metocean parameters.

Study description and aim:
In the context of uncertainty propagation, the aim of the study is to improve the usual methodologies where approximations (not always justified), such as brutal discretization of continuous random processes and statement of independence of random inputs, are common.

Functional data analysis and metamodeling techniques are in themselves two subjects of great interest. Brought together in the context of uncertainty propagation they can be seen as promising tools for the study of complex and computationally expensive models. Indeed, the fast development of instrumental analysis equipment and modern measurement devises provides huge amounts of data as high-resolution digitized functions. As a consequence, functional data analysis has become a growing research field simultaneously with the development of functional regression model. Recent/current works have, on the one hand, extended classical metamodeling techniques to models with mixed functional/scalar inputs and scalar outputs, and, on the other hand, to models with scalar inputs and mixed functional/scalar outputs. Non-exhaustively, this generalization goes from linear and kernel regression, k-nearest neighbours, neural network, inverse regression, density based inverse regression to RKHS based regression. Studies on the case of models dealing with both functional inputs and outputs data are more rare but still classical in many real life phenomena studies. Despite the non-negligible amount of work achieved on this specific field, the efficiency analysis, the industrial implementation, and the use of these new methods are still at their early stages.

Sensitivity Analysis (SA) aims at quantifying the uncertainty in an input-output model. The objective is to identify and to rank the input variables that drive the uncertainty of the model output. SA objective is to reduce the model dimension and/or to detect the most influential parameters. More precisely, global SA is a stochastic approach based on the density of the joint probability distribution function of the output and the inputs of the regression model. In this context, a subject of interest is the comprehensive definition and analysis of sensitivity indicators when random inputs are dependent. Recent work have been achieved following this scope, but the task is complex and many indicators definitions are possible.

Work expected from the candidate:

The applicant will

- Analyse, implement and compare different approaches for the propagation of mixed functional/scalar inputs. A bibliography and reflection will be done on the methods adapted to full (input-output) functional model treatment,

- Analyse, implement and compare different approaches for the global sensitivity analysis of dependent random inputs,

- define the limitations of the above methods and open new perspectives.

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