Post-doctoral Proposal for 2019:

Development of statistic methods for conditional and targeted sensitivity analysis of numerical simulators

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Application on a thermal-hydraulic calculation case simulating accidental scenario in a Pressurized Water Reactor

Duration: 12 months, potentially renewable.

Location: CEA, Cadarache Center (13108 Saint-Paul-Lez-Durance, France)

Host Laboratory of CEA Cadarache: Systems Studies and Modeling Laboratory

CEA supervisor: Amandine MARREL

Keywords: Uncertainty quantification, sensitivity analysis, safety and risk assessment

Context:

Many phenomena are modeled by mathematical equations which are implemented and solved using complex computer codes. These computer models often take as inputs a high number of uncertain variables and parameters. To provide guidance to a better understanding of this kind of modeling and in order to reduce the response uncertainties most effectively, sensitivity measures of the input importance on the response variability can be useful (Saltelli et al. [2000]). In the framework of safety and risk assessment studies, we are interested in critical domain of the studied phenomenon i.e. areas where the output takes critical values from a safety viewpoint (failure output domain, the output exceeds a given safety threshold). In this framework, we can distinguish two kinds of specific sensitivity analysis:

- **target sensitivity analysis** which aims at measuring the influence of the inputs over the occurrence of the critical event (*i.e. when the model output belongs to the critical domain*);
- **conditional sensitivity analysis** measuring the influence of the inputs over the output within the critical domain only, ignoring what happens outside.

The objective of the post-doctoral fellowship is to develop new statistical tools for these specific sensitivity analyses and to apply them on industrial nuclear applications.

Detailed description:

After a previous post-doctoral fellowship in 2017, new statistical tools derived from dependence measures (Da Veiga [2014], Gretton et al. [2005]) have been developed for these specific sensitivity analyses (voir Raguet and Marrel [2018]). Different versions of these new tools (with or without a smoothing function) as well as an adapted approach of the Sobol 'indices (Sobol [1993]) have been tested on several analytical examples. First numerical results, very encouraging, illustrate the relevance of the dependence measures for target and conditional sensitivity analyses and highlight the advantages and limits of the various tools (sensitivity indices and associated estimators). Several perspectives to this work have also been identified in order to extend the application of these tools (multivariate variables for example) and to improve the

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robustness of estimators. First, these tools will have to be tested in the case where the probability of the zone of failure is low. They also have to be applied on real industrial applications, such as thermal-hydraulics code which simulates a primary loss of coolant accident on a pressurized water reactor, in collaboration with EDF. In parallel, to generalize their use, some methodological points need to be further investigated. In particular, the invariance properties of indices (and associated statistical independence tests, De Lozzo and Marrel [2016]) with respect to transformation of the output have to be studied. Moreover, from a practical point of view, the estimation of the indices from Quasi Monte Carlo samples has to be compared to “pure” Monte Carlo estimators (comparison of statistical properties of estimators and adaptation of independence tests with Quasi Monte Carlo estimators).

Finally, in view of the sustainability and deployment of these tools on other industrial applications, their integration into the URANIE platform, developed by the CEA for the treatment of uncertainties, is also planned. The postdoctoral researcher will be responsible for producing the specifications needed to integrate these tools into the URANIE platform. These specifications may be generic and common to the OPENTURNS platform developed by EDF (platform also dedicated to the uncertainty treatment).

Project

This post-doctoral contract is funded by the Simulation program of CEA and is part of the "Uncertainty" project of the Tripartite CEA-EDF-FRAMATOME Institute.

Formation and Skills

PhD in applied mathematics, specialized in probabilities and statistics, programming skills: R software, C++ and/or Python, ability to publish.

Contact

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References

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