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POST-DOCTORATE PROPOSAL

Reference : **PDOC-DTIS-2018-04**

Host Laboratory at ONERA :

Branch : Traitement de l'Information et du Signal

Location (ONERA center) : Palaiseau or Toulouse

Department : Information processing and systems

Unit : Multidisciplinary Methods and Integrated Concepts

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Title : Multidisciplinary design in the presence of high dimensional uncertainties

Keywords : uncertainty propagation, sensitivity analysis, multidisciplinary design, MDO

Context :

Uncertainty quantification by a probabilistic approach is often used in the design and optimization of complex systems to evaluate its reliability or to carry out robust optimization, *etc*. The multidisciplinary characteristic of complex system results in a challenge for uncertainty propagation especially for high dimensional problems. The objective of this post-doctorate is to study and propose new methodologies for uncertainty propagation on multidisciplinary in the presence of high dimensional couplings (for instance couplings between pressure and displacement meshes).

Subject description :

Two key axes will be investigated during the post-doctorate :

- Sensitivity analysis for multidisciplinary coupled systems allowing for a high dimensional problem to order the influence of the uncertain parameters with respect to a quantity of interest. This analysis should enable to identify the most critical uncertainties requiring a refinement of such dimensions. Moreover, it should enable to freeze the non-influential variables and therefore to decrease the dimension of the studied problem. The quantification of the influences by sensitivity indices (*e.g.* DGSM, Sobol, Morris) on a multidisciplinary system will be developed in order to take into account the specificity due to the presence of coupling variables in high dimension. Indeed, even if a variable may have a high influence (or low influence respectively) at a disciplinary level, it does not necessarily result in a high influence (or low influence respectively) at the system level. Therefore, the developed method should take into account this challenge.

- Estimation of failure probability for coupled multidisciplinary systems in high dimension. Multidisciplinary Design Optimization under uncertainty (UMDO) requires constraint evaluations which can be expressed as a probability of failure. For complex constraints and rare events, this step is time consuming in UMDO. In this second step, the post-doctorate objective will be to develop new failure probability estimation techniques in high dimensions for coupled system in order to improve the solving of UMDO problems. Recent works based

on Chaos Polynomial Expansions or Kriging Partial Least Square seems adapted to model uncertain couplings between physical models in high dimensions. However, for multidisciplinary systems, an adapted surrogate model refinement strategy according to the different disciplines should be developed in order to control the uncertainty associated to the different surrogate models near the failure regions and to ensure the accuracy and robustness of the estimated probability of failure.

In order to validate the proposed methodologies, a test case for multidisciplinary design of civil aircraft will be considered. This conceptual design test case involves numerous couplings (CFD for aerodynamics and FEM for structural design) and diverse uncertain parameters. This test case will allow comparing the proposed developments with reference techniques to assess their performance.

Expected outputs:

- Development of methodologies and associated python module,
- Validation on aerospace test case
- Publication of journal article.

References :

- Arnst, M., Ghanem, R., Phipps, E. and Red-Horse, J. (2014), Reduced chaos expansions with random coefficients in reduced-dimensional stochastic modeling of coupled problems. Int. J. Numer. Meth. Engng, 97: 352–376. doi:10.1002/nme.4595
- Balesdent, Mathieu, et al. "Advanced Space Vehicle Design Taking into Account Multidisciplinary Couplings and Mixed Epistemic/Aleatory Uncertainties." Space Engineering. Springer International Publishing, 2016. 1-48.
- Blatman, Géraud, and Bruno Sudret. "An adaptive algorithm to build up sparse polynomial chaos expansions for stochastic finite element analysis." Probabilistic Engineering Mechanics 25.2 (2010): 183-197.
- Bouhlel, Mohamed Amine, et al. "Improving kriging surrogates of high-dimensional design models by Partial Least Squares dimension reduction." Structural and Multidisciplinary Optimization 53.5 (2016): 935-952.
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- Dubreuil, S., et al. "Propagation of modeling uncertainty by polynomial chaos expansion in multidisciplinary analysis." Journal of Mechanical Design 138.11 (2016): 111411.
- Morio, Jérôme, and Mathieu Balesdent. Estimation of Rare Event Probabilities in Complex Aerospace and Other Systems: A Practical Approach. Woodhead Publishing, 2015.

Duration : 12 months, can be renew once

Net wages: around 25 k€ / year

Candidate Skills

Formation : Doctorat

Skills :

- Applied mathematics
- Knowledge in aerospace recommanded
- Ability to publish