Enriching process in metamodeling : Software development and validation

Master level (6 months from MARCH 2016)

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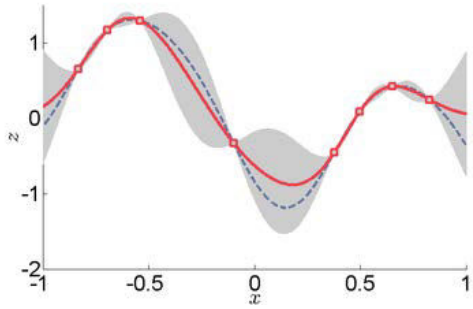
Context:

The aerodynamic & mechanical structures optimization such as turbomachinery blades is now part of the engineering design process. The main idea is to search for a set of parameterized aerodynamic shapes, optimizing the aerodynamic performance and/or Static/dynamic mechanical criteria while satisfying a set of constraints. Industrial optimization problems, involving simulation of more representative physical models with a in very large design space ("high fidelity" models often PDE and analysis through finite element). Each computer experiment is highly time consuming (several hours for a transient nonlinear complex analysis for example). The strategy currently implemented is to build a very fast metamodel (so-called RSM, response surface polynomial or more complex meta-model such as Kriging or Gaussian Process) to represent the system response based on the input (design) parameters, and thus replace each costly call to the computer code in the process optimization by a call to a metamodel.



The main idea is to add new functionalities into an open source python library (developed in OpenMDAO framework) to "reduce" a costly computational code:

1. Adding capabilities of handling multiple outputs
2. Building criteria to improve the accuracy of DOE
3. Estimation of sensitivities of Sobol indices.

The main result of this internship will be to display the new capabilities for two real test cases: the first one coming from automobile crash scenarios (MOPTA) and the second one coming from structural optimization problem for an aircraft. Meanwhile some benchmarking of the developed algorithm will be performed with available toolboxes.

The course will be paid (monthly bonus: € 500) and carried out in the laboratories of the ISAE-SUPAERO in the joint research framework with ONERA (ECR MDO).

Background

- Mathematical background is a must.
- Experience with developing codes in Matlab/Python is appreciated.

References

- Queipo, N.V., Haftka, R.T., Shyy, W., Goel, T., Vaidyanathan, R., Tucker, P.K. (2005), "Surrogate-based analysis and optimization," Progress in Aerospace Sciences, 41, 1–28.
- D. Gorissen, I. Couckuyt, P. Demeester, T. Dhaene, K. Crombecq, (2010), "A Surrogate Modeling and Adaptive Sampling Toolbox for Computer Based Design," Journal of Machine Learning Research, Vol. 11, pp. 2051–2055, July 2010.
- T-Q. Pham, A. Kamusella, H. Neubert, "Auto-Extraction of Modelica Code from Finite Element Analysis or Measurement Data," 8th International Modelica Conference, 20–22 March 2011 in Dresden.
- Forrester, Alexander, Andras Sobester, and Andy Keane, Engineering design via surrogate modelling: a practical guide, John Wiley & Sons, 2008.
- Gaussian Processes for Machine Learning, Carl Edward Rasmussen and Chris Williams, the MIT Press, 2006, online version.
- Statistical Interpolation of Spatial Data: Some Theory for Kriging, Michael L. Stein, Springer, 1999.

- openMDAO framework : http://openmdao.org/
  J. Gray, K. T. Moore, T. A. Hearn, and B. A. Naylor, "Standard platform for benchmarking multidisciplinary design analysis and optimization architectures," Aiaa journal, vol. 51, iss. 10, pp. 2380-2394, 2013.
- MOPTA : http://www.miguelanjos.com/jones-benchmark
  D. Jones, "Large-scale multi-disciplinary mass optimization in the auto industry", Modeling and optimization: Therory and application (MOPTA) 2008 conference.

- Toolboxes:
  - Scikit-learn : http://scikit-learn.org/stable/
  - The Framework for Uncertainty Quantification UQLab : http://www.uqlab.com/
  - The MATLAB Model-Based Calibration Toolbox http://fr.mathworks.com/products/mbc/