Laboratoire **Roberval**
Unité de recherche en mécanique

SEMINAIRE ROBERVAL
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A priori DoE-based sensitivity analysis benefits for electromechanical FE models updating and vibration-based mixed FE–experimental inverse identification of materials effective behaviors

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Abstract

Recently, a robust (considering design parameters high uncertainties) mixed Finite Element (FE)-experimental (vibration) and evolutionary (Genetic Algorithm-GA) multi-objective optimization-based inverse identification procedure was suggested, by the Lecturer and coworkers, for electromechanical 3D FE model updating [1], and elastic composite host [2], surface-bonded piezoceramic patch elastic [3], and piezoelectric and dielectric [4] behaviors characterization. It combines full factorial (considering 3 or 2 levels) numerical design of experiments (DoE)-based optional *a priori* sensitivity analyses, Response Surface Methodology (RSM) meta-modelling of the multi-modes (2, 3 or 8) frequency dependence on design parameters (3, 5, 6, 8 or 9) and non-sorting genetic algorithms of first (NSGA) [1] and second (NSGA II) [2-4] generations. Sensitivity analyses serve here to assess the effects of each application's design parameters in order to detect, and then retain the most influent ones for meta-modelling, while the resulting meta-models replace 3D FE computations within the GA optimizations.

Based on earlier works [1-4], this seminar focuses on the benefits of the a priori DoE-based sensitivity analyses option for robust optimal design of piezoelectric smart structures. It will be shown that *a priori* sensitivity analyses are beneficial to:

- Design parameters reduction to the necessary ones only, depending on the geometry and kinematics of the analyzed host structure;
- Multi-modes number reduction to the most affected or the electromechanically coupled only, depending on the position (location) of the surface-bonded piezoceramic patch and the vibrating structure modes types (x-z transverse bending, x-y in-plane bending or torsion);
- Meta-models number reduction for the evolutionary multi-objective optimization. This is a consequence of the previous benefit;
- Computational cost reduction, resulting from the reduction of the design variables, multi-modes and meta-models;
- Optimization outputs quality, in the sense that obtained results are physically realistic (expected) and coherent with engineering (ad-hoc) practice.

These benefits will be illustrated for each of the application investigated in the earlier works [1-4].

References

[1] M. Hamdi, S. Ghanmi, A. Benjeddou, R. Nasri. Robust electromechanical finite element updating for piezoelectric structures effective coupling prediction. *J. Intel. Mater. Syst. Struct.*, **25**, 137-154, 2014.

[2] M. Hamdi A. Benjeddou. Robust multi-objective evolutionary optimization-based inverse identification of three-dimensional elastic behaviour of multilayer unidirectional fibre composites. Chapter in *Smart Structures and Materials*, A.L. Araujo (Editor), Springer, 2016 (in press).

[3] A. Benjeddou, M. Hamdi. Robust inverse identification of the effective three-dimensional elastic behaviour of a piezoceramic patch bonded to a multilayer unidirectional fibre composite. *Compos. Struct.*, **151**, 58-69, 2016.

[4] A. Benjeddou, M. Hamdi, S. Ghanmi. Robust inverse identification of piezoelectric and dielectric effective behaviours of a bonded patch to a composite plate. *Smart. Struct. Syst.* **12**, 523-545, 2013.

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