Ph.D. Thesis Offer

LMN INSA de Rouen 2025

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Title : : **Stochastic analysis of nonlinear dynamic systems using subdomain methods**

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Description of the subject:

Accounting for parameter uncertainty is a particularly critical issue in nonlinear dynamics. Indeed, small uncertainties in geometry, boundary conditions, or material properties can have a significant impact on the dynamic behavior of the structure. This sensitivity to small parameter variations results from a generally nonlinear dependence between the dynamic response of a system and its parameters. For example, natural frequencies and mode shapes are generally related to system parameters by strongly nonlinear relationships.

When structural analysis requires great finesse, a second difficulty is added: the large size of the finite element (FE) model thus generated can induce computational costs that often remain prohibitive, despite advances in computer hardware. It then becomes necessary to develop strategies to reduce the size of the models while preserving their fidelity.

A first approach consists of constructing an approximate model that significantly reduces the number of unknowns to be processed. Subdomain methods are often the best and sometimes the only strategy in this family for the dynamic analysis of complex structures. The use of these methods is justified both by advantages in terms of numerical efficiency and by taking into account the organizational constraints of large projects. Many methods of condensation and dynamic substructuring have been developed in parallel with the evolution of current computing resources.

An alternative is to experimentally obtain data that can provide a description of the dynamic behavior of the structure under analysis. The data can be analyzed using various methods of representation, interpolation, and extrapolation to predict the structure's behavior outside the measurement points. These two approaches generally lead to partial results, incompletely characterizing the structure's behavior. For example, only the behavior of a portion of the structure may be accessible, or the approximations may only be suitable for a limited frequency range. To obtain better results, it is necessary to combine them. Furthermore, significant challenges remain in the nonlinear domain, particularly when uncertainties must be taken into account or extrapolation must be performed outside the envelope of the points under consideration.

This doctoral thesis aims to advance the field of analysis of nonlinear structures in the presence of uncertain variables. Its dual objective is, on the one hand, the extension of nonlinear substructuring methods to stochastic situations and, on the other hand, the coupling of these results to experimental data. We will study

- The direct problem, once given the probabilistic model of the input parameters, consists of propagating the variability of these parameters through the mechanical model.
- The inverse problem which consists of determining the maximum uncertainty domain of the input parameters such that the selected criteria are respected.

Travail de thèse:
1. Extension of substructuring methods for stochastic structures involving nonlinearities.
2. Use of experimentally obtained substructure vibration modes.
3. Extension of substructuring methods for modeling nonhomogeneous random uncertainties.

Bibliography:

https://www.researchgate.net/profile/Abdelkhalak-Elhami/research

https://www.amazon.fr/Livres-Abdelkhalak-El-Hami/s?i=stripbooks&rh=n%3A301061%2Cp_27%3AAbdelkhalak%2BEl%2BHami&page=2&qid=1743373805&xpid=SxXkTRO3INsrT&ref=sr_pg_2