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Structure dynamic reliability: A hybrid approach and robust meta-models

N. Rabhi [a], M. Guedri [a,*], H. Hassis [b], N. Bouhaddi [c]

[a] Preparatory Engineering Institute of Nabeul (IPEIN), 8000 M'rezgua, Nabeul, Tunisia
[b] Civil Engineering Laboratory, Ecole Nationale d'Ingénieurs de Tunis (ENIT), BP 37, Le Belvédère 1002, Tunis, Tunisia
[c] FEMTO-ST Institute UMR 6174, Applied Mechanics Laboratory R. Chaléat, University of Franche-Comté, 24 Chemin de l'Epitaphe, 25000 Besançon, France

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ABSTRACT

Mathematical modeling of physical systems is essential to understand and, if possible, control such systems. However, insufficient information may be available about the level of uncertainty related to material properties, geometric parameters, boundary conditions and the applied loads. In the context of structural reliability, the uncertainties may be uncontrollable when designing for robustness. These problems in the modeling of the uncertainties are often complicated by the model's inability to describe the physical phenomena that are involved. In this paper, the proposed approach combines a dynamic reliability method and a meta-model (reduced model) to obtain good results in terms of the reliability and optimization of such systems. Using the available information about the uncertain design parameters, we use the hybrid model coupling of the possibility and probability approaches for the propagation of the uncertainties in the model. The proposed method was implemented on theoretical structures with different meta-models. The results are compared with the Monte Carlo simulations. This allowed us to prove the robustness and efficiency of the proposed methodology for reliability calculations of complex dynamic structures.

1. Introduction

Reliability calculations for complex mechanical problems increasingly necessitate the use of the finite element method (FEM), which has to present the physical phenomenon being studied as faithfully as possible.

In this paper we apply these probability and possibility methods to reliability problems. However, in terms of the available information, we may need methods to process the imprecision, which will allow more a realistic modeling of the uncertainties relative to the structural modeling.

Some reliability problems can be resolved analytically, but they are often simple theoretical problems. Monte Carlo simulations are widely used, despite their high calculation times, and are used as a reference for our calculations.

Several strategies have been developed to reduce the number of samples that we needed. We distinguish the importance sampling [1] which is based on design point estimation undertaken at the beginning, by carrying out some sampling and by only holding the point belonging to the failure domain, which is nearest to the origin of the normalized space. The density of the importance sample can then be estimated and centered at this point. A precise sampling can then

* Corresponding author. Tel.: +216 72 220 053; fax: +216 72 220 181.
E-mail address: mohamed.guedri@isetn.rnu.tn (M. Guedri).

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