REANALYSIS TECHNIQUES IN STOCHASTIC MECHANICS

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Abstract

In various structural design and optimization problems it is necessary to repeatedly evaluate the response of the structure for numerous modified designs. Specifically, mechanical and geometrical parameters may change and eventually structural components can be added or deleted leading also to a change in the number of the degrees of freedom in the pertinent finite element model. Since, in general, the response cannot be expressed explicitly in terms of the structure properties, any structural modification requires a considerable computational effort. These computational mechanics problematic are to the base of the increasing interest in the reanalysis techniques in last two decades. Indeed, the aim of the reanalysis is the valuation of the structural response of modified systems using the results relative to the original structure, called as reference structure, so reducing the computational effort. In this regard the reanalysis techniques are classified as topological or non-topological if the modifications lead to a change of the degrees of freedom of the system or not.

Therefore, the reanalysis is able to cope with both static and dynamic response evaluation. A review of the static response reanalysis techniques can be found in [1] and more recently in [2], in which it is shown that the most common reanalysis methods, namely: the Combined Approximation (CA); the Theorems of Structural Variations (TSV) and the Virtual Distortion Method (VDM), can be derived from the Sherman-Morrison-Woodbury formula [3,4]. The previous quoted methods can be also adopted for topological modifications [5]. A review of the earliest contribution in this topic can be found in [6-7].

Most of the existing reanalysis methods in dynamics are concentrated on resolving the modal problem, in which only modifications to eigenvalues and eigenmodes are considered. This problem is solved quasi-statically in the frequency domain (no dependence on time is investigated). A review of some eigenproblem reanalysis methods can be found in [7-8]. Recently the authors, proposed a method for the dynamic response reanalysis in the time domain [9-10], the method evaluates the structural response by the dynamic modification approach [11] without solving any eigenproblem. The method can be adopted to evaluate both deterministic and stochastic response.

In the framework of stochastic mechanics two problems are the object of this study. In the first one the reanalysis technique herein proposed is used for Monte Carlo simulations of structures with uncertain parameters. Lastly, the presented approach is also applied for the random response of linear systems subjected to random loadings. In the former problem several analyses of slightly modified systems are required. Indeed for systems with uncertain parameters, if the Monte Carlo simulation is adopted, the computational effort is quite onerous. In this regard, the main steps involved in a Monte Carlo study require the simulation of a set of random variable from a theoretical distribution of structural parameters, the deterministic analysis of the response for each set of variables, and the evaluation of the response statistics determined by repeating several times the deterministic analysis for each individual new simulation. Clearly, to avoid the very onerous required repeated analyses, the deterministic dynamic response reanalysis is computationally very useful. In this regard, the Dynamic Modification Method (DMM) proposed in [11] is extensively used and resorted to cope with the dynamic response reanalysis in time domain. According to this method all the dynamic modifications are assumed pseudo-forces and the response of the modified

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structure is retrieved starting from the knowledge of the transition matrix and the eigenvectors of the original structure.

Moreover, via this approach the response of nonclassically damped system is determined without the evaluation of complex quantities. Lastly, the present approach is also applied to the random response of linear systems subjected to random loadings. For simplicity's sake only the case of non topological modifications is considered..

The numerical results show the accuracy and the computational efficiency of the described approach to the analysis of multi-degrees-of-freedom (MDoF) systems. Remarkably, it is also shown that the approach is computationally very effective, in order to show this the CPU reduction time is evaluated.

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