

The dynamic response of structures with bounded uncertainties

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Abstract

Uncertainty plays an important role in the performance of structures. In this paper, we focus on the dynamic response of structures with bounded uncertainties, and present a new method, which is based on the vertex solution theorem, to determine the supremum and infimum of the dynamic response. This approach solves the exact interval for the first-order deviation of the dynamic response and avoids interval extension, where the length of the interval increases significantly due to the intermediate calculations. Hence, the only approximation in this method is that the second order terms in the equation of motion are neglected. Thus the method is more accurate than the perturbation method and provides tighter bounds on the response.

1 Introduction

Dynamic response simulations are required in the design and analysis of structures for many engineering problems. However, many types of uncertainties exist in dynamic systems, related to the geometry (e.g. the dimensions of a beam section), the material characteristics (e.g. Young's modulus, shear modulus, Poisson's ratio or mass density), and the exterior environment (e.g. thermal properties or exterior loads). The analysis of uncertainty plays an important role in determining the adequate performance of structures.

Many researchers (for example references [1-4]) have investigated the dynamic response of structures with probabilistic parameters. However these probabilistic analysis approaches demand significant knowledge about the uncertain parameters that may not be available easily in practice. Thus, an alternative, non-probabilistic conceptual framework [5, 6] based on interval mathematics [7, 8] arose, in which only the bounds of uncertain parameters are required, and knowledge of the probabilistic distributions is not necessary. Most of the interval analysis for structure has considered the static response [9, 10] or the eigenvalue problem [11, 12], and the dynamic response problem has received little attention [13, 14]. Qiu and Wang [14] presented a non-probabilistic interval analysis method to estimate the range of the dynamic response of structures, based on a Taylor series expansion. The disadvantages of this method are the increase in the response intervals due to interval extension arising from the intermediate calculations, and the requirement to calculate the first derivatives of the response to the uncertain parameters.

In this paper, a new method is presented to determine the supremum and infimum of the dynamic response with bounded uncertainties. In Section 2, we formulate the problem and in Section 3 present the first-order perturbation of the structural dynamic response problem. The method to calculate the exact bounds of the deviation in the dynamic response by the vertex solution theorem is presented, and the supremum and infimum of the dynamic responses is obtained in Section 4. Examples of interval dynamic problems are used to illustrate the application of the proposed method in Section 5, and the results are compared to the perturbation method. The examples consist of a two degree of freedom discrete system and a two dimensional truss structure with six nodes and eight elements.

Designers Guide To Dynamic Response Of Structures

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