Automated Structural and Multi-Body Dynamics: Application to Linear and Non-Linear Finite Element Vehicle Models.

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ABSTRACT

The main objective of the present work is to develop and apply a systematic numerical process leading to an automated determination of dynamic response of complex mechanical systems. Such systems arise frequently as a result of strict requirements posed by industrial needs on the accuracy obtained in the response of various mechanical components or systems. Usually, the components of complex systems are geometrically discretized and represented by finite element models, involving a quite large number of degrees of freedom, which may sometimes reach or overcome the order of a million. The basic idea is to first reduce the dimension of the systems examined by applying appropriate methodologies in either the time domain or the frequency domain. Application of these methodologies results in an efficient reduction of the dimensions and helps the efforts towards a systematic and comprehensive study of the dynamics exhibited by large order mechanical models with nonlinear characteristics. Apart from increasing the computational efficiency and speed, the reduction of the system dimensions makes amenable the application of several numerical techniques for determining the dynamic response of the complex systems, which are applicable and efficient for low order dynamical systems.

The methodolody developed was adjusted so that it starts by reading all the necessary data from the Pre-processor ANSA in order to set up the corresponding equations of motion. After reducing the order of these equations, a number of analyses are performed, including static and kinematic analysis, eigenvalue, transient response, frequency response and random analysis as well as parametric identification and optimization. Once the analysis chosen is completed, the process is finished by directing the results obtained to the Post-processing system μETA. It is important to note that the process is developed in a general way, so that it allows hybrid modellings resulting from coupling of numerical with experimental data or results obtained from coupled mechanical and acoustics models.

The accuracy and effectiveness of the methodology applied in the code developed is illustrated by numerical results obtained for complex vehicle body and engine structures. In particular, frequency spectra of several response quantities related to model performance were constructed for motions resulting from periodic and random excitation. In cases where it is feasible, direct comparison is performed (in terms of accuracy, memory required, data transferred and numerical speed) with similar results obtained from NASTRAN and ADAMS, for structural and multi-body dynamics applications, respectively. An advantage of the code developed is the ability to determine periodic steady state response of periodically excited nonlinear dynamical systems in a direct way. This is particularly important, since the results obtained indicate that there appear substantial differences in the response diagrams of the fully nonlinear models examined and their corresponding linearized versions, which are commonly used in practice.

keywords: automated finite element analysis, structural and multi-body dynamics, linear and non-linear steady state analysis, random analysis, parametric identification, optimization