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Two methods for gradient-based optimization in nonlinear structural dynamics

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Abstract

We present two methods for gradient-based optimization in nonlinear structural dynamics, including a time-domain reduction using the incremental harmonic balance method (IHB) [1], and a space-domain reduction with explicit modal coupling coefficients (EMCC) [2]. The IHB method highlights the nonlinear governing equation in the frequency domain. With four precomputed matrices, it can be easily implemented by using a map relation between common finite element matrices and their counterparts in the frequency domain. The EMCC method can be viewed as a natural extension of linear eigenvalue problems. It involves finite element discretization, explicit modal expansion and extraction of norm form coefficients that qualitatively and quantitatively characterize the nonlinear dynamic response. Both methods are important in different aspects. While optimization based on IHB method in conjunction with alternating frequency and time domain method is capable to handle general nonlinearity [3], optimization based on EMCC is especially suitable for nonlinear effects that can be modelled by a potential. The methods are currently being applied in design optimization of nonlinear micro-resonators for frequency generation and conversion. Interesting examples are offered for tailoring the hardening and softening behavior and the essential intermodal coupling effect.

References:
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