Efficient complex modal analysis for noisy fractional-order systems

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Abstract

This study provides an efficient way to perform the dynamic analysis of multi-degree-of-freedom (MDOF) systems ruled by coupled motion equations with fractional derivatives. Specifically, coupled fractional-derivative terms are force-displacement relations, which may suitably model the mechanical behavior of several structures and structural elements, e.g. civil structures with vibration isolators, continuous beams of viscoelastic materials, biological tissues, bones, etc.

The proposed method is based on a proper fractional-order state variable analysis in conjunction with a complex modal transformation that allows to decouple the equations of motion. As the number of the degrees of freedom increases, computational efforts are reduced by a numerical approximation based on an appropriate truncation of the complex modal expansion. It is shown that the proposed approach ensures a good level of the approximation and a relevant reduction of the computational efforts.

In the numerical applications, multi-degree-of-freedom systems forced by deterministic and stationary stochastic forces are considered. For the stochastic case, response power spectral densities are compared with Monte Carlo simulation data. For both deterministic and stochastic cases, the numerical applications show the capabilities of the present method.

Keywords: fractional calculus, multi-degree-of-freedom system, state variable analysis, modal truncation.

Acknowledgments

The author gratefully acknowledge the support received from the Italian Ministry of University and Research, through the PRIN 2015 funding scheme (project 2015JW9NJT Advanced mechanical modeling of new materials and structures for the solution of 2020 Horizon challenges).