The use of rational approximation for linearization of models that are nonlinear in the frequency

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Finite element models for the analysis of vibrations typically have a quadratic dependency on the frequency. This makes the finite element method suitable for eigenvalue computations and time integration, by a formulation as a first order system, which we call a linearization.

The study of new damping materials often leads to nonlinear frequency dependencies, sometimes represented by a rational functions but, often, by truly nonlinear functions. In classical analyses, vibrations are studied in the frequency domain. The nonlinear frequency dependency is an issue for algorithms for fast frequency sweeping. In the context of numerical algorithms for digital twins, time integration of mathematical models is required, which is not straightforward for models that are not linear or polynomial in the frequency.

We will discuss rational approximation and linearization of nonlinear frequency dependencies and their use for fast frequency sweeping and time integration. In particular, we use the AAA rational approximation and the associated linearization based on the barycentric Lagrange formulation of rational functions, which is successfully used for solving nonlinear eigenvalue problems. We show how real valued matrices can be obtained. We also show how the parameters can be tuned to obtain a stable linear model.