Frequency-weighted damping via non smooth optimization and fast computation of QEPs

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Abstract

We consider frequency-weighted damping optimization for vibrating systems described by a second-order differential equation. The goal is to determine viscosity values such that eigenvalues are kept away from certain undesirable areas on the imaginary axis. To this end, we present two complementary techniques. First, we propose new frameworks using nonsmooth constrained optimization problem, whose solutions both damp undesirable frequency bands and maintain stability of the system. These frameworks also allow us to weight which frequency bands are the most important to damp. Second, we also propose a fast new eigensolver for the structured quadratic eigenvalue problems that appear in such vibration systems. In order to be efficient, our new eigensolver exploits special properties of diagonal-plus-rank-one complex symmetric matrices, which we leverage by showing how each quadratic eigenvalue problem can be transformed into a short sequence of such linear eigenvalue problems. The result is an eigensolver that is substantially faster than existing techniques. By combining this new solver with our new optimization frameworks, we obtain our overall algorithm for fast computation of optimal viscosities. The efficiency and performance of our new methods are verified and illustrated on several numerical examples.