Damping optimization of linear vibrating systems and related problems

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Consider a damped linear vibrational system described by the differential equation

$$M\ddot{x} + D\dot{x} + Kx = 0\,, \qquad x(0) = x_0, \quad \dot{x}(0) = \dot{x}_0\,,$$

where M, D, K are mass, damping and stiffness matrix, respectively.

A very important question arises in considerations of such systems: *for given mass and stiffness determine the damping matrix so as to insure an optimal evanescence.*

It can be shown that this optimization problem is equivalent to the following minimization problem:

$$\mathrm{trace}(X) = \min\,,$$

where X is solution of the following Lyapunov euqation:

$$AX + XA^T = -GG^T\,,$$

here A is $2n \times 2n$ matrix obtained from M, D and K, and G is matrix with full column rank, and rank(G) $\ll n$.

We will present a several results about efficient solution of this minimization problem and some related problems. We will show a new estimates for the eigenvalue decay of the solution X which include the influence of the right-hand side G on the eigenvalue decay rate of the solution. Also, we will present an efficient algorithm for the minimization of trace(X) using a low rank Cholesky ADI method based on a new set of ADI parameters. Our latest approach to this minimization process includes non-exact minimization using projection procedure based on the second-order Arnoldi method. We will also present some new results about solution of Sylvester equation.