

# A Rank Minimization Heuristic with Application to Minimum Order System Approximation

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Several problems arising in control system analysis and design, such as reduced order controller synthesis, involve minimizing the rank of a matrix variable subject to linear matrix inequality (LMI) constraints. Except in some special cases, solving this rank minimization problem (globally) is very difficult. One simple and surprisingly effective heuristic, applicable when the matrix variable is symmetric and positive semidefinite, is to minimize its trace in place of its rank. This results in a semidefinite program (SDP) which can be efficiently solved. In this paper we describe a generalization of the trace heuristic that applies to general non-symmetric, even non-square, matrices, and reduces to the trace heuristic when the matrix is positive semidefinite. The heuristic is to replace the (nonconvex) rank objective with the sum of the singular values of the matrix, which is the dual of the spectral norm. We show that this problem can be reduced to an SDP, hence efficiently solved. To motivate the heuristic, we show that the dual spectral norm is the convex envelope of the rank on the set of matrices with norm less than one. We demonstrate the method on the problem of minimum order system approximation.

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