Fast Approximation of the Stability Radius and the H_∞ Norm for Large-Scale Linear Dynamical Systems

Michael L. Overton
Courant Institute, N.Y.U.
mo1@nyu.edu

Joint work with Nicola Guglielmi (L'Aquila),
Mert Gürbüzbalaban (M.I.T.) and Tim Mitchell (M.P.I.)

The stability radius and the H_∞ norm are well-known quantities in the robust analysis of linear dynamical systems with output feedback. These two quantities, which are reciprocals of each other in the simplest interesting case, respectively measure how much system uncertainty can be tolerated without losing stability, and how much an input disturbance may be magnified in the output. The standard method for computing them, the Boyd-Balakrishnan-Bruinsma-Steinbuch algorithm from 1990, is globally and quadratically convergent, but its cubic cost per iteration makes it inapplicable to large-scale dynamical systems. We present a new class of efficient methods for approximating the stability radius and the H_∞ norm, based on iterative methods to find rightmost points of spectral value sets, which are generalizations of pseudospectra for modeling the linear fractional matrix transformations that arise naturally in analyzing output feedback. We also discuss a method for approximating the real structured stability radius, which offers additional challenges. Finally, we describe our new public-domain MATLAB toolbox for low-order controller synthesis, HIFOOS (H-infinity fixed-order optimization — sparse). This offers a possible alternative to popular model order reduction techniques by applying fixed-order controller design directly to large-scale dynamical systems.