Development and Validation of LMI Conditions for State-Feedback based Equivalent D-Stabilization of Discrete-time Systems

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Abstract. It is well established that D-stability-related time-domain specifications, such as settling time, damping ratio, and maximum peak overshoot, exhibit convex properties in case of continuous-time systems. However, the same convexity does not hold for discrete-time systems. This paper addresses this challenge by proposing convex approximations for the inherently non-convex time-domain specifications for discrete-time systems. To achieve this, the study formulates Linear Matrix Inequality (LMI) conditions that enhance equivalent D-stability regions, thereby improving both analysis and controller synthesis related to discrete-time systems. Additionally, the paper develops LMI-based conditions for synthesis of the state-feedback controller leading to implicit D-stabilization of discrete-time plants.
To validate the effectiveness of these results, the proposed method is applied to second-order Spring-Mass-Damper (SMD) system as well as higher-order benchmark problems, such as the Magnetic Levitation System (MLS). The results demonstrate significant improvements in system stability and performance.
Furthermore, the performance of the proposed state-feedback controller for the MLS is analyzed using the Integral of Absolute Error (IAE) and compared with existing results. The comparative analysis highlights the advantages of the proposed method in achieving better stability and control precision.

Keywords: Linear Matrix Inequality, D-stability regions, Discrete-time System, Spring Mass Damper, Magnetic Levitation System