Contribution ID: **11** Type: **Poster**

KLAP: KYP lemma based low rank approximation for passivation

Monday 26 May 2025 17:10 (1h 50m)

We present a novel passivation method, called KLAP, for linear time-invariant systems based on the Kalman-Yakubovich-Popov (KYP) lemma in low-rank factorized form.
The passivation problem in our framework corresponds to finding a perturbation to a given non-passive system that renders the system passive while minimizing the $\mathcal{H}_2$ distance between the original non-passive and the resulting passive system.
We show that this problem can be formulated as an unconstrained optimization problem whose objective function can be differentiated efficiently even in large-scale settings.
We show that any global minimizer of the unconstrained problem yields the same passive system. Furthermore, we prove that, in the absence of a feedthrough term, every local minimizer is also a global minimizer. For cases involving a non-trivial feedthrough term, we analyze global minimizers in relation to the extremal solutions of the algebraic Riccati equations, which can serve as tools for identifying local minima.
To solve the resulting numerical optimization problem efficiently, we propose an initialization strategy based on modifying the feedthrough term and a restart strategy when it is likely that the optimization has converged to a local minimum.
Numerical examples illustrate the effectiveness of the proposed method.

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Session Classification: Poster Blitz & Poster Section