Accurate $\mathscr{H}_\infty$-Norm Estimation via Finite-Frequency Norms of Local Parametric Models

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1 Background

Accurate $\mathscr{H}_\infty$-norm estimation is of critical importance for robust control design. Selecting an appropriate size of the uncertainty is crucial for the performance of the resulting robust controller. On the one hand, if the uncertainty is underestimated, there are no stability nor performance guarantees. On the other hand, if the uncertainty is overestimated, the system may become overly conservative.

2 Problem Formulation

Traditional algorithms to estimate the $\mathscr{H}_\infty$ norm consider a discrete frequency grid. Hence, the $\mathscr{H}_\infty$-norm estimate is based solely on the at-grid frequencies which causes inter-grid errors. Consequently, potential resonances may be overlooked. This research aims to develop an algorithm to accurately and reliably determine the $\mathscr{H}_\infty$ norm with a limited amount of data and limited user effort.

3 Approach

The key idea is the exploit the local smoothness over frequency by identifying local parametric models [1]. Since these local models are parametric, they can be evaluated continuously in their local frequency range, which enable the estimation of the inter-grid behavior [2]. The main idea is to estimate the global $\mathscr{H}_\infty$ norm by estimating the finite-frequency L_∞ norm of the local models through the generalized KYP lemma [3].

4 Results

The developed approach is applied to a multivariable motion system. The resulting model uncertainty is shown in Fig. 1. In Fig. 2, the maximum singular values of the uncertainty and the resulting local models are depicted for a large frequency range. When studying the interpolation performance of the local models, it is clear that the true inter-grid behavior is accurately modeled. Moreover, the simulation shows that the $\mathscr{H}_\infty$ norm is accurately estimated. Overall, the simulation example shows that the method proposed in this paper offers an accurate and reliable approach to estimate $\mathscr{H}_\infty$ norm.

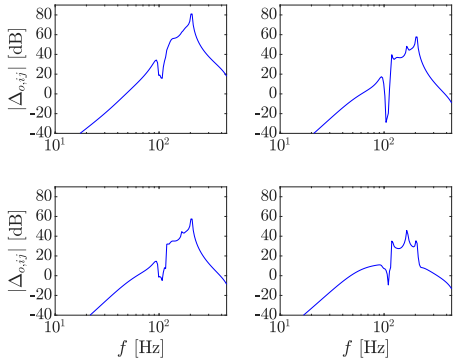

Figure 1: Bode magnitude diagram of the uncertainty Δ (——).

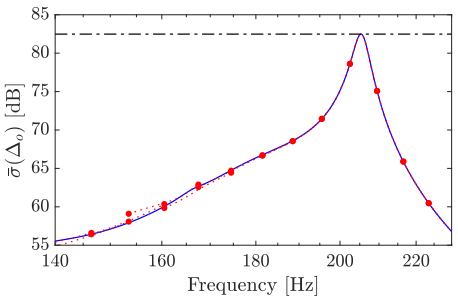

Figure 2: Bode magnitude diagram of the singular values: true uncertainty $\bar{\sigma}(\Delta)$ (——), local modeling estimate $\bar{\sigma}(\tilde{\Delta}_k)$ (• · · •).

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References

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