Otto von Guericke University Magdeburg
Institute for Analysis and Numerics
Max Planck Institute for Dynamics of Complex Technical Systems
Computational Methods in Systems and Control Theory

Summer Term 2017
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Model Reduction of Dynamical Systems
Homework 2

Deadline: 19 May 2017

Problem 1. *Asymptotic waveform evaluation*

(a) Implement the asymptotic waveform evaluation method (using the pole-residue framework) as a function. The function should take system matrices and reduced order as inputs and return the poles and residues of the Padé approximation.

Test your function on the clamped beam model `beam.mat` [1]. Compare the Bode magnitude plots over the frequency interval $\omega \in [10^{-3}, 10^{3}]$ of the original and the reduced-order models for different reduced orders.

(b) Compare the above implementation with implicit Padé approximation, using V and W, satisfying

$$\operatorname{range}(V) = \mathcal{K}_r\left(A^{-1}, A^{-1}B\right) \text{ and } \operatorname{range}(W) = \mathcal{K}_r\left(A^{-T}, A^{-T}C^T\right),$$

as projection matrices (use the Arnoldi method to compute V and W).

Problem 2. *Model reduction by interpolation*

Implement a function for interpolating a SISO LTI system

$$\begin{aligned} \dot{x}(t) &= Ax(t) + Bu(t), \\ y(t) &= Cx(t), \end{aligned}$$

at specified interpolation points, assuming the interpolation points are pairwise distinct and closed under conjugation. Use projection-based approach, i.e. project using matrices V and W such that

$$\operatorname{range}(V) = \operatorname{span}\left\{(\sigma_1 I - A)^{-1}B, \ldots, (\sigma_r I - A)^{-1}B\right\}$$

and

$$\operatorname{range}(W) = \operatorname{span}\left\{(\sigma_1 I - A)^{-T}C^T, \ldots, (\sigma_r I - A)^{-T}C^T\right\},$$

where $\sigma_1, \ldots, \sigma_r$ are the interpolation points. Ensure that V and W are real matrices.

Test your function on the clamped beam model `beam.mat` [1].

References

[1] http://slicot.org/20-site/126-benchmark-examples-for-model-reduction.

You can send your solutions in two ways:

1. **by sending them to `mlinaric@mpi-magdeburg.mpg.de`,**
2. **by adding Petar Mlinarić (username `pmli`) to your GitLab or Bitbucket project.**

Solutions should be written in a PDF file (created using LaTeX) or a Jupyter notebook. When sending emails, please add `[mor17]` to the subject line.