Numerically reliable identification of complex systems

Citation for published version (APA):

Document license:
CC BY

Document status and date:
Published: 01/09/2014

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.
Numerically reliable identification of complex systems

Frequency domain identification

Ingredients for parametric identification:
- Data
- Model structure
- Cost function

\[ V(\theta) = \left| W(\xi) \left( P_0(\xi) - \hat{P}(\xi, \theta) \right) \right|^2 \]

Numerical aspects
Conditioning:
- SK: \( \kappa(A) \)
- IV: \( \kappa(C^T A) \approx \kappa(A)^2 \)
- \( \kappa(A) \) is very high (beyond \( 10^{16} \)) \( \Rightarrow \) inaccurate solution
- partial solutions
  - frequency scaling and scaling of columns of \( A \)
  - use orthonormal/rational bases [2]: OBF, FLBF, ...
- full solution: (bi-)orthonormal basis

Benchmarking and comparison of multiple methods

Method:

Rational bases:
- Frequency localising basis [3]:
  \[ \phi_{L,p} = \frac{|\phi_p|}{S + a_p} \prod_{l=1}^{p-1} \left( \frac{S}{S + a_l} \right) \]
- band-pass filters: approximate orthogonality
- Vector fitting [4]

Open issues:
- poles \( \phi_{RL} \) cancelled by iterative SK/IV reweighting
- convergence properties VF

Proposed solutions:
- SK-FLBF using pole relocation [4]
- IV-Vector fitting

Data dependent bases:
- scalar Forsythe polynomials [5]
- bi-orthonormal block-polynomials → optimal conditioning IV

Bi-bilinear form [7]:
\[ \theta_j = \sum_{k=1}^{n} W_{j,k} \phi_{k}(\xi) \]

Reference:

Experimental results

Table 1: Average conditioning

<table>
<thead>
<tr>
<th>Orth</th>
<th>1.000 ...</th>
<th>1.000 ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLBF</td>
<td>4.8 ( \cdot ) 10^3</td>
<td>1.1 ( \cdot ) 10^10</td>
</tr>
<tr>
<td>VF</td>
<td>9.2 ( \cdot ) 10^5</td>
<td>3.6 ( \cdot ) 10^8</td>
</tr>
<tr>
<td>Mon</td>
<td>2.8 ( \cdot ) 10^{-2}</td>
<td>1.0 ( \cdot ) 10^{-2}</td>
</tr>
<tr>
<td>MonBC</td>
<td>510</td>
<td>7.0 ( \cdot ) 10^{-6}</td>
</tr>
</tbody>
</table>

Bi-orthonormal basis is promising \( \Rightarrow \) optimal conditioning.

Ongoing research

- theoretical properties of bi-orthonormal basis
- efficient computation of bi-orthonormal basis
- implementation in a MIMO toolbox

References

Acknowledgments
Robbert van Herpen is gratefully acknowledged for his contributions. This research is supported by NWO/SWEN VENI grant 13073, ASML research and the TUE Impulse program.