

# Identifying a C-arc medical X-ray system : a 2D-LRM approach

**Citation for published version (APA):**

van der Maas, A., van der Maas, R. J. R., Voorhoeve, R. J., & Oomen, T. A. E. (2016). Identifying a C-arc medical X-ray system : a 2D-LRM approach. In *35th Benelux Meeting on Systems and Control, March 22-24, 2016, Soesterberg, The Netherlands* (pp. 131)

**Document status and date:**

Published: 01/01/2016

**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.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.tue.nl/taverne](http://www.tue.nl/taverne)

**Take down policy**

If you believe that this document breaches copyright please contact us at:

[openaccess@tue.nl](mailto:openaccess@tue.nl)

providing details and we will investigate your claim.

# Identifying a C-arc Medical X-ray System: A 2D-LRM Approach

Annemiek van der Maas, Rick van der Maas, Robbert Voorhoeve, Tom Oomen  
 Department of Mechanical Engineering, Eindhoven University of Technology  
 P.O. Box 513, 5300 MB Eindhoven, The Netherlands

Email: { A.v.d.Maas, R.J.R.v.d.Maas, R.J.Voorhoeve, T.A.E.Oomen}@tue.nl

## 1 Introduction

The calibration of a C-arc based medical X-ray systems, as depicted in Fig. 1, can either be approached from a motion control point of view or using model-based approaches, [1]. The dynamical behavior of the system is depending on the operating conditions; the system is linear parameter varying (LPV). This provides a systematic framework for controller design. The aim of this work is to develop a nonparametric identification approach to obtain accurate FRFs of the X-ray system for a set of “frozen” workpoints. These accurate FRFs can be the basis for both controller design and (local) LPV modeling, [2], [3], [4].

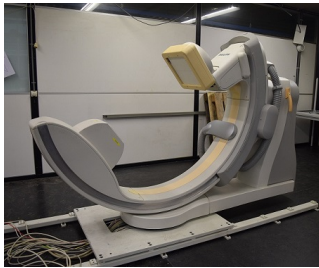


Figure 1: Philips Allura Centron interventional X-ray System.

## 2 Local Parametric Methods for LPV systems

State-of-the-art identification methods exploit the smoothness of a FRF over the frequencies, [2]. Here, we propose a nD-LRM to also exploit smoothness over the scheduling parameters, [5]. In particular, for traditional local parametric methods, a rational function is fitted on a local frequency window for each LTI experiment, as indicated in Fig. 2a. The proposed nD-LRM approach identifies the systems’ dynamics on a local surface, as indicated in Fig. 2b.

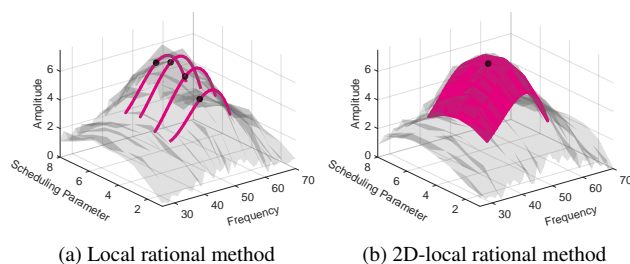


Figure 2: Proposed approach, compared to traditional LTI methods.

## 3 Measurement Results

The medical X-ray system in Fig. 1 has several degrees of freedom, which each cause varying dynamics. Here, a single degree of freedom has been identified at 13 individual poses of the system. The data obtained from the same identification experiments are processed using traditional local rational methods and using the proposed 2D-LRM approach, for which the resulting Bode diagrams are shown in Fig. 3.

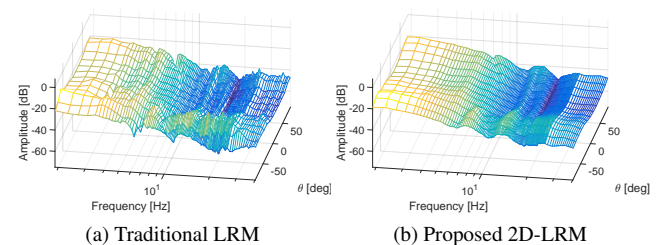


Figure 3: Comparison of traditional method with the proposed method based on measurements.

## 4 Conclusions

For the medical X-ray system, the proposed nD-LRM approach shows significant potential in terms of estimation quality and measurement times. With identical measurement times, smoother Bode diagrams with significantly reduced variances are obtained. These improved identified FRFs are directly usable for state estimations or controller design, [4].

## References

- [1] R. van der Maas, B. de Jager, M. Steinbuch, and J. Dries, “Model-Based geometric calibration for medical X-ray systems”, in *Medical Physics*, 42(11), pp. 6170-6181, 2015.
- [2] J. Schoukens, G. Vandersteen, K. Barbé, and R. Pintelon, “Nonparametric Preprocessing in System Identification: a Powerful Tool”, *European Journal of Control*, 2009(3), pp. 260 - 274, 2009.
- [3] F. Felici, J. van Wingerden, and M. Verhaegen, “Subspace identification of MIMO LPV systems using a periodic scheduling sequence”, *Automatica*, 43, pp. 1684 - 1697, 2007.
- [4] R. Tóth, “Modeling and Identification of Linear Parameter-Varying Systems”, Springer-Verlag Berlin, 2010.
- [5] R. van der Maas, A. van der Maas, T. Oomen, “Accurate Frequency Response Function Identification of LPV Systems : A 2D Local Parametric Modeling Approach”, in *Proc. of the Conf. on Decision and Ctrl.*, pp. 1465 - 1470, 2015