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STADIUS
Center for Dynamical Systems, Signal Processing and Data Analytics

STADIUS Newsletter

June 2026

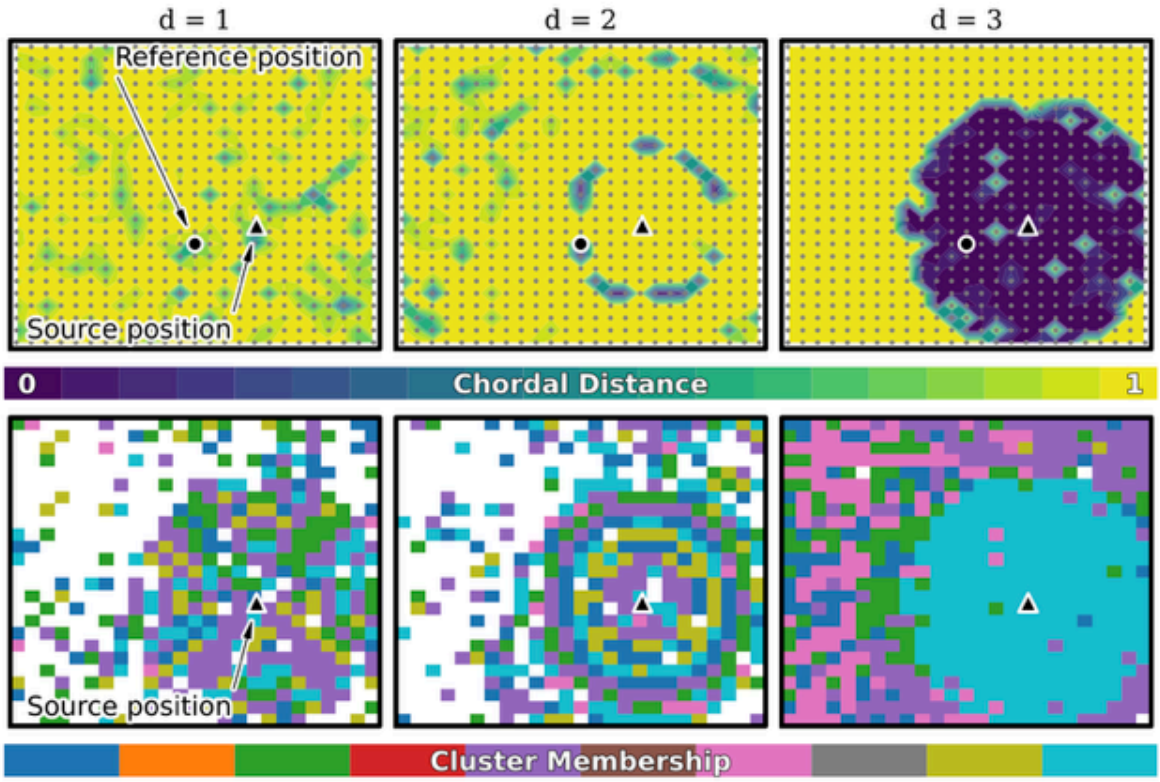
Research of the month by Matthias Blochberger

"Joint higher-order low-rank tensor decompositions for multichannel acoustic system compression"

Work under the supervision of Toon van Waterschoot, Marc Moonen, Jan Ostergaard (AAU) and Jesper Jensen (Oticon, AAU)

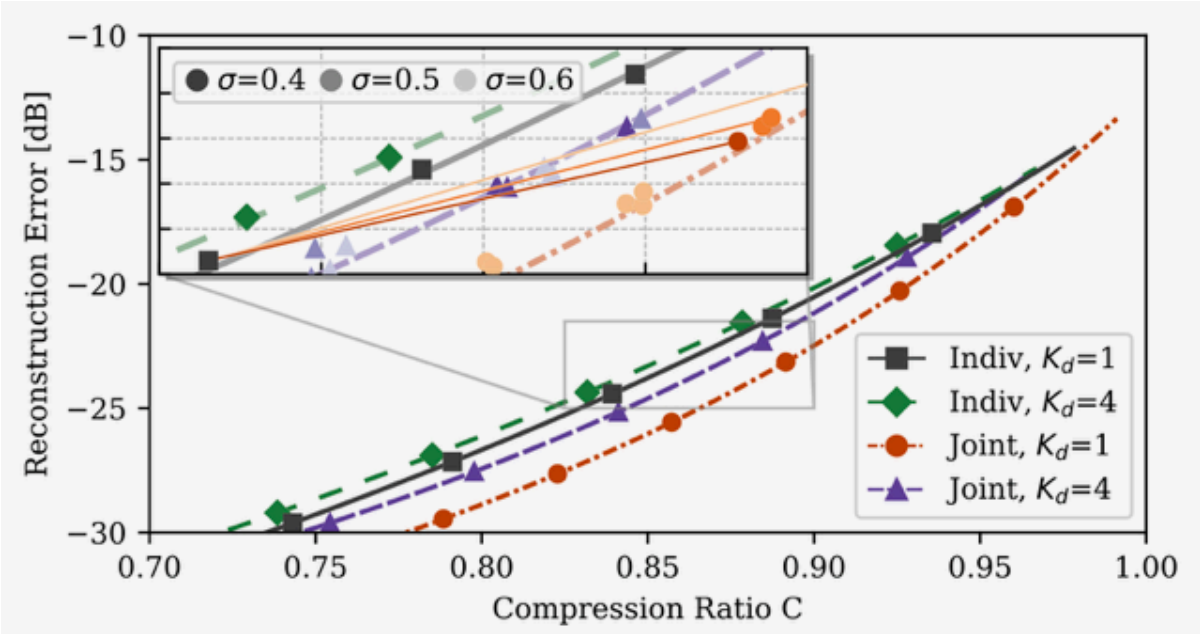
Room impulse responses (RIRs) describe how sound travels from a loudspeaker to a microphone in a room, including direct sound, reflections, and reverberation. They are fundamental in room acoustic signal processing and are used in applications such as spatial audio, virtual and augmented reality, source localisation, speech enhancement, and acoustic simulation. However, realistic room impulse responses can be very long, ranging from thousands to hundreds of thousands of samples, and multichannel acoustic systems often require many such responses to be stored and processed. This makes accurate room acoustic modelling expensive in terms of both memory and computation.
In this work, we propose a compact representation of multichannel room impulse responses using higher-order low-rank tensor decompositions. The key idea is to exploit structure that is already present in room acoustics. Classical pole-zero models describe room responses through resonant modes of the room. We show that, when room impulse responses are rearranged into tensors, these pole-zero models naturally lead to low-rank tensor representations: early reflections appear as sparse rank-one components, while late reverberation can be represented through low-rank factors determined by the room's poles.

Building on this connection, we introduce two joint compression methods for multichannel acoustic systems. The first method, stacked multichannel block term decomposition (SMCBTD), arranges all room impulse responses into one higher-order tensor and compresses them jointly. The second method, joint multichannel block term decomposition (JMCBTD), allows selected tensor factors to be shared across channels. These shared factors are identified using spectral clustering on factor-subspace affinity graphs, enabling the method to automatically detect which acoustic components are similar across different source–receiver paths. Both methods are optimized using an alternating higher-order orthogonal iteration procedure.



Top row: Top views of a shoebox room with the Chordal distance between tensorized RIRs at a reference position and a grid of positions over the room. The distances are computed from the factor subspaces in mode d = 1, 2, 3, respectively. Darker colors indicate higher similarity (lower distance). **Bottom row:** Top views of the same room with spectral clustering applied. The clusters are indicated by different colors and show the spatial arrangement of the microphone positions within each cluster.

We evaluated the proposed methods on simulated rooms and three measured datasets. The results show that joint tensor-based compression consistently achieves lower reconstruction error than separate single-channel decompositions and a generalized low-rank matrix approximation (GLRAM) baseline at equal compression ratios. The largest gains are obtained using scalar-core decompositions, corresponding to canonical polyadic decomposition, which supports the theoretical link between pole-zero room acoustic models and low-rank tensor representations. We also find that a three-mode tensorization offers a practical balance between compression performance, memory use, and computational cost.



This figure shows the mean reconstruction error versus compression rate comparing individual BTD and the proposed JMCBTD for different core ranks and clustering parameters. The data is from the simulated compact microphone array at the near-field position, and tensorization order D=3. It shows that by

clustering decomposition factors and sharing them across multiple channels, yields lower reconstruction error at the same compression rate. We can see that the performance gain is more pronounced for lower core ranks.

The compressed representations are not only storage-efficient, but also useful for downstream processing, in particular efficient multichannel convolution. This makes the proposed framework relevant for scalable spatial audio rendering, virtual acoustic environments, and real-time room acoustic signal processing.

This work is presented in the internal report (to be submitted for publication):
"Joint Higher-Order Low-Rank Tensor Decompositions for Multichannel Acoustic System Compression"
M. Blochberger, F. Elvander, J. Østergaard, and T. van Waterschoot.
👉 Link: https://ftp.esat.kuleuven.be/pub/stadius/mblochbe/25-119.pdf

Events @ Stadius

PhD defense – Kathleen MacWilliam
Spatiotemporal Modelling and Inference of Room Acoustics
When: 02 July, 13:30 – 15:30
Where: Aula van de Tweede Hoofdwet
Speaker: Kathleen MacWilliam

For more information about STADIUS events please visit the STADIUS Event webpages.

Don't forget to check the website of VAIA for a wide choice of courses on (aspects of) AI: www.vaia.be

New colleagues

A warm welcome to new personnel at STADIUS!



Hey all!
My name is **Joseph Ereifej**, and I recently joined KU Leuven to pursue my PhD at STADIUS under the supervision of Dr. Rodolphe Sepulchre. I completed my BS and MS studies in Electrical and Computer Engineering at the University of Pittsburgh in Pittsburgh, Pennsylvania. There, my research focused on developing digital hardware implementations of neuron models and deploying them onto FPGAs and ASICs. At KU Leuven, I hope to explore these concepts within the scope of control systems with neuromorphic sensing devices. Outside of academia, I enjoy climbing outdoors, playing folk music on my guitar, partner dancing, and cooking. I look forward to meeting and working with you all over the next few years.

-Joe

We wish the best of luck to the researchers who are leaving STADIUS

Best of luck!

- **Miguel Bhagubai**, a postdoctoral researcher in Maarten De Vos's group, is leaving STADIUS to embark on a new career in industry. He will soon join Dataroots in Leuven as a Machine Learning Engineer.
- **Fernando Crema Garcia**, a PhD researcher in Bart De Moor's group, is also leaving STADIUS. You may still see him around over the coming weeks as he wraps up his research projects and finalizes his PhD thesis.

Thank you both for your contributions to our research division. We wish you all the best for the future.



Current and planned visitors

- **Andrea Costanzo** - in the group of Alexander Bertrand (since February)
- **Anna Fusari -** in the group of Toon van Waterschoot (since February)
- **Jiande Chen** - in the group of Maarten De Vos (since April)
- **Sunghyun Koo** - in the group of Rodolphe Sepulchre (since May)
- **Sofie Haesaert** - in the group of Panos Patrinos (since May)
- **Alberto Bernardini** - in the group of Rodolphe Sepulchre (since June)
- **Jaap van der Aar** - in the group of Maarten De Vos (since July)
- **Changrui Liu** - in the group of Rodolphe Sepulchre (arriving in September)
- **Zhiran Ma** - in the group of Panos Patrinos (arriving in September)Jaap van der Aar,

Enjoy your research visit at STADIUS !!!

Recently defended PhD theses

Congratulations to the new PhD graduates!

- **08/06/2026 – Lukas Vanpoucke** *"A Polynomial Approach to Globally Optimal Multidimensional System Identification*"
  Promotor: Bart De Moor

Thesis

- **23/06/2026 – Matthias Blochberger** *"Room-Acoustic Modelling, Identification and Compression for Acoustic Sensor Networks"*
  Promotors: Toon van Waterschoot, Marc Moonen, Jan Østergaard (AAU) and Jesper Jensen (Oticon, AAU)

Thesis

- **25/06/2026 – Bilgesu Çakmak** *"Distributed Sound Source Localization in Wireless Acoustic Sensor Networks"*
  Promotors: Toon van Waterschoot, Thomas Dietzen, Patrick Naylor (Imperial College London)

Thesis

Publications

Here's the monthly STADIUS Publications Digest, including new reports that have been added to the publications database. Please remember to have your own reports added in the publications database and make sure your entries are kept up to date (status submitted/accepted/published) at all times.

Contact Ida for new additions and updates; do not add/update database content yourself.

26-95
Roebben A., Van Peer J., Jensen J., van Waterschoot T., Wouters J., Moonen M., ``Hybrid Algorithm Design for Noise Reduction with the Generalised Eigenvalue Decomposition Multi-Channel Wiener Filter'', Technical Report 26-95, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2026.

26-96
Vanpoucke L., *A Polynomial Approach to Globally Optimal Multidimensional System Identification*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Jun. 2026, 240 p.
Lirias number: 4416650.

26-97
Weiss S., Schlecht S.J., Moonen M., ``Best Least Squares Paraunitary Approximation for an Extended Range of Polynomial Matrices'', Technical Report 26-97, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2026. Accepted for publication in *34th European Signal Processing Conference (EUSIPCO 2026)*.
Lirias number: 4427382.

26-98
Blochberger M., *Room-Acoustic Modelling, Identification and Compression for Acoustic Sensor Networks*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Jun. 2026
Lirias number: 4424829.

26-99
Cakmak B., *Distributed Sound Source Localization in Wirelss Acoustic Sensor Networks*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Jun. 2026
Lirias number: 4418976.

26-101
Kariotakis E., Bodard A., Patrinos P., Konar A., ``Optimal quasi-clique detection via Lasry-Lions double envelopes'', in *Proc. of the 51st IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2026)*, Barcelona, Spain, May 2026, pp. 416-420.
Lirias number: 4395039.

26-102
Wang J., Themelis A., Markovsky I., Patrinos P., ``A Lasry-Lions Envelope Approach for Mathematical Programs with Complementarity Constraints'', *Journal of optimization theory and applications*, vol. 209, no. 3, 2026, Art Nb 85 p.
Lirias number: 4426015.

26-103
Wang J., Hemelhof L., Markovsky I., Patrinos P., ``Fast data-driven iterative learning control for linear system with output disturbance'', *Journal of the Franklin Institute*, vol. 363, no. 3, 2026, Art. Nb. 108414 p.
Lirias number: 4399317.

26-104
Bouillon A., Bodard A., Patrinos P., Nuyens D., Samaey G., ``A localized consensus-based sampling algorithms'', Technical Report 26-104, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2026. Accepted for publication in *Inverse problems*.
Lirias number: 4416376.

26-105
Rotaru T., Patrinos P., Glineur F., ``Tight convergence rates in gradient mapping for the difference-of-convex algorithm'', in *51th International Conference on Modeling, Computation and Optimization in Information Systems and Management Science*, (N., and

N., eds.), vol. 1688 of mph{Lecture Notes in Networks and Systems}, Springer, 2026.
Lirias number: 4394527.

26-106

Huremagic B., *Analysis and Sharing of Whole Genome Sequencing data*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), May 2026, ? p.
Lirias number: 4395250.

26-107

Angelou A., Behmandpoor P., Moonen M., ``Master-Assisted Distributed Uplink Operation for User-Centric Cell-Free Massive MIMO Networks'', Technical Report 26-107, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2026.



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