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STADIUS
Center for Dynamical Systems, Signal Processing and Data Analytics



December 2023

RESEARCH ▪ AWARDS ▪ NEWS ▪ EVENTS ▪ STAFF UPDATE ▪ PUBLICATIONS

Welcome to the December edition of the STADIUS Newsletter! Enjoy the Christmas break!

We wish you not to be in the Santa's control group!

Research of the month by Elisa Tengan

"Spatial audio analysis with constrained microphone setups in adverse acoustic conditions"

Work under supervision of Toon van Waterschoot

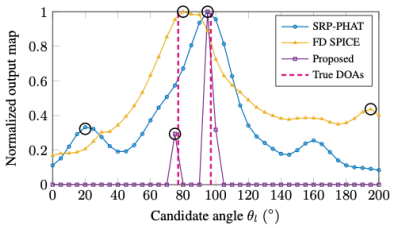

Figure 1: Normalized output maps obtained for different candidate directions in the case of two sources located at 77° and 97°, with SNR $= -6$ dB and $T_{60} = 0.2$ s.

The **spatial information** contained in recorded microphone signals has a fundamental role in the characterization of acoustic environments. Furthermore, it can be **exploited in digital audio processing frameworks** for enhancing a desired source signal, benefiting applications such as hands-free telephony, hearing devices, human-machine interfaces, and acoustic monitoring systems.

This thesis focuses on the **development and evaluation of audio processing methods for estimating and applying spatial information** while addressing a selection of challenges encountered in different applications. The estimation of spatial information is, in this thesis, limited to the problem of source localization. Firstly,

two approaches for single-channel source localization are presented, motivated by the limitations in spatial audio analysis capabilities imposed by single-microphone setups or devices in which simultaneous access to multiple microphone signals is unreliable. These methods solve group-sparse optimization problems, identifying peaks in the estimated PSD vector relative to a given angular dictionary.

Building on the insights gained from evaluating the single-channel localization methods, a multi-channel source localization method is also presented. **This method estimates the DOA of multiple broadband sound sources** through a similar group-sparse optimization problem, modeling an observed broadband steered response power (SRP) map as a linear combination of PSDs instead. Simulation results demonstrate that the proposed method outperforms conventional methods in certain multi-source scenarios and maintains comparable performance to others while being more computationally efficient. Moreover, it **shows superior performance in cases with closely located sources**, as illustrated in the first figure.

Shifting focus from source localization, the thesis explores spatial information for speech enhancement in challenging acoustic conditions, specifically employing a microphone array in an unmanned aerial vehicle (UAV), subject to high ego-noise levels. **It introduces an experimental methodology for measuring ego-noise emissions and investigates spatial filtering-based methods for speech enhancement.** A speech enhancement method using ego-noise references is presented, based on the prior-knowledge multi-channel Wiener filter (PK-MWF) and speech presence probability (SPP) estimates. Additionally, the method's development is extended to explicitly incorporate estimated DOA information on the target speaker, yielding an alternative implementation. The proposed approaches are evaluated over experimental recordings obtained with a drone operating at constant thrust, in a simulated hovering condition, as illustrated in the second figure. Results indicate the **importance of reliable speech activity estimates in the**

performance of spatial filtering-based methods such as the PK-MWF. It is shown that employing the DOA-based implementation of the PK-MWF filter significantly improves the signal-to-noise ratio (SNR) of the filtered signal when compared to the use of PK-MWF with SPP estimated from one of the embedded microphones, whereas the perceptual improvement is compromised. Furthermore, it is shown that combining both DOA and SPP-based implementations of PK-MWF can improve performance in terms of perceptual speech quality.

See also:

- Speech enhancement using ego-noise references with a microphone array embedded in an unmanned aerial vehicle
- Direction-of-arrival and power spectral density estimation using a single directional microphone and group-sparse optimization

Awards



André Kahn Sleep Award for Elisabeth Heremans

We are proud to announce that in November, Elisabeth Heremans, a PhD researcher supervised by Maarten De Vos, has won the "André Kahn Sleep Award".

The "André Kahn Sleep Award" is a scientific award with the specific aim to promote and reward original research related to the field of **sleep and sleep medicine** of individual members. It is granted to the laureate of the scientific contest organized during the Autumn meeting of the Belgian Association for Sleep Research and Sleep Medicine (BASS).

Read more about **BASS** and the **Award.**

News



Bart De Moor appointed as a Board member of EIC

On December 13, 2023, the European Commissioner for Innovation, Iliana Ivanova, revealed the newest additions to the European Innovation Council (EIC) Board. The EIC, at the forefront of fostering innovation across Europe, welcomes a diverse set of leaders to steer its strategic direction and drive implementation.
We're proud to announce that **Bart De Moor** has been selected as one of the esteemed Board members.
For more information on this announcement, you can visit the official EIC news page and explore the profiles of all EIC Board members here.

Yves Moreau speaks up in The Washington Post

In a recent Washington Post article, Yves Moreau emphasized **China's unregulated utilization of DNA databases**. Despite President Biden expressing worries about Chinese human rights violations, especially regarding mass DNA collection, the White House lifted sanctions on the Institute of Forensic Science, a significant network of police labs in China.
Read More in Washington Post.

Johan Suykens - keynote speaker at IEEE WCCI 2024

Johan Suykens will deliver a keynote talk at the **IEEE World Congress on Computational Intelligence** (IEEE WCCI 2024) for the International Joint Conference on Neural Networks (IJCNN), taking place on June 20 - July 5 2024 in Yokohama Japan.

And more:

- A paper "Primal-Attention: Self-attention through Asymmetric Kernel SVD in Primal Representation" authored by STADIUS researchers **Yingyi Chen, Qinghua Tao, Francesco Tonin and Johan Suykens** was presented at Thirty-seventh Conference on Neural Information Processing Systems (NeurIPS 2023).

Events @ STADIUS

Seminar: Research visit in the USA: sharing experience and practical tips
When: **10/01/2024 16:00 - 17:00**

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 in courses on

Where: **B01.35**
By: **Meanie Nijs & Lola Botman**

(aspects of) AI:
www.vaia.be

ERC Back to the Roots Seminar: Fast and Stable Roots of Polynomials via Companion Matrices
When: **06/02/2024, 17:00**
Where: **Aula Arenbergkasteel**
Organised by: **Bart De Moor**

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

Best of luck!



- **Nasim Shabani Lalani,** a researcher from the group of Yves Moreau is leaving STADIUS at the end of the year.

All the best on the new carreer path!

Recently defended PhD theses

In December 2 STADIUSans have defended their PhDs. Congratulations!

- **01/12/2023 Christof Vermeersch** "The (Block) Macaulay Matrix Solving Systems of Multivariate Polynomial Equations and Multiparameter Eigenvalue Problems", PhD thesis under the supervision of Bart De Moor
- **21/12/2023 Francesco Tonin** "Optimization Frameworks for Deep Kernel Machines", PhD thesis under the supervision of Johan Suykens

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Recently approved Projects

In December we got some good news about the following projects being approved:

- **FWO Project** "The Boundary Element Method as a State-Space Realization Problem"
  - supervisor: Toon van Waterschoot
  - co-supervisor: Randall Ali (University of Surrey)
- **C3** "HELIXON: Hybride, efficiënte en vloeiende interpolatie van geluid in uitgebreide realiteit
  - supervisor: Toon van Waterschoot
  - co-supervisor: Steven Devleminck
- **EuroHPC:** Innovative Algorithms Applications On European Exascale Supercomputers

    - coordinator: Barcelona Supercomputing Center
    - supervisor @STADIUS: Panos Patrinos
- **VLAIO IM:** Reliable pose estimation for (equestrian) sports: Optimization-based algorithms for physics-aware AI
    - grantee: Mathijs Schuurmans
    - promotor: Panos Patrinos
- **VLAIO BM:** "AI approach to Lung Function Trajectory Analysis for early detection and monitoring of respiratory disease"
    - grantee: Ahmed Elmahy
    - promotor: Maarten De Vos

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Publication Digest

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.

23-157

Epure A., Dietzen T., Foubert K., De Backer J., van Waterschoot T., "Room Acoustic Treatment and Design of a Recording Setup for Music Therapy", in *Proc. of the Forum Acusticum 2023*, Turin, Italy, Sep. 2023.
Lirias number: 4129390.

23-158

MÃ¼ller K., Ã‡akmak B., Didier P., Doclo S., Ostergaard J., Wolff T., "Head Orientation Estimation with Distributed Microphones using Speech Radiation Patterns", in *Proc. of the 57th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove (ASILOMAR)*, Pacific Grove, United States, Oct. 2023.
Lirias number: 4129379.

23-159

Blochberger M., Ostergaard J., Ali R., Moonen M., Elvander F., Jensen J., van Waterschoot T., "Adaptive Coding in Wireless Acoustic Sensor Networks for Distributed Blind System Identification", Technical Report 23-159, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2023.*2023 Asilomar Conference on Signals, Systems, and Computers*, pp. 1-5.
Lirias number: 4129384.

23-160

Uyttendaele Y., De Moor B., "Transcribing manuscripts in mensural notation : A comprehensive pipeline", Technical Report 23-160, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2023. *2023 Asilomar Conference on Signals, Systems, and Computers*.

23-161

Green R. W., Heremans R., FischerovÃi D., Yan J., Eriksson L., Mascilini F., Testa A. C., Franchi D., Sladkevicius P., Valentin L., OpolskienÄ— G., Haak L. A., Fruscio R., Chiappa V., Van Holsbeke C., Alcazar J. L., Cibula D., Guerriero S., FrÃ¼hauf F., Carlson J., Mestdagh W., Bourne T., Timmerman D., Van den Bosch T., Epstein E., "Development and internal validation of competing risks models that combine demographic and ultrasound features with the ESMO/ESGO/ESTRO or ESGO/ESTRO/ESP risk classifications to predict recurrence of progression in endometrial cancer: results from the IETA-4 cohort follow-up study.", Technical Report 23-161, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2023. Accepted for publication.

23-162

Lagauw S., De Moor B., "Least Squares Projection Onto the Behavior for SISO LTI Models", Technical Report 23-162, ESAT-STADIUS, KU Leuven (Leuven, Belgium),

2023. Accepted for publication.

23-163

Tengan E., Dietzen T., Elvander F., van Waterschoot T., "Multi-source direction-of-arrival estimation using steered response power and group-sparse optimization", Technical Report 23-163, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2023.

23-166

Fitzpatrick B., De Sena E., van Waterschoot T., "Efficiently predicting the optimal truncation number of the multiple expansion method", Technical Report 23-166, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2023.

23-167

Fitzpatrick B., De Sena E., van Waterschoot T., "A convolution quadrature based lighting" solver for the wave equation", Technical Report 23-167, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2023.

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ida.tassens@kuleuven.be .

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