Show message in browser

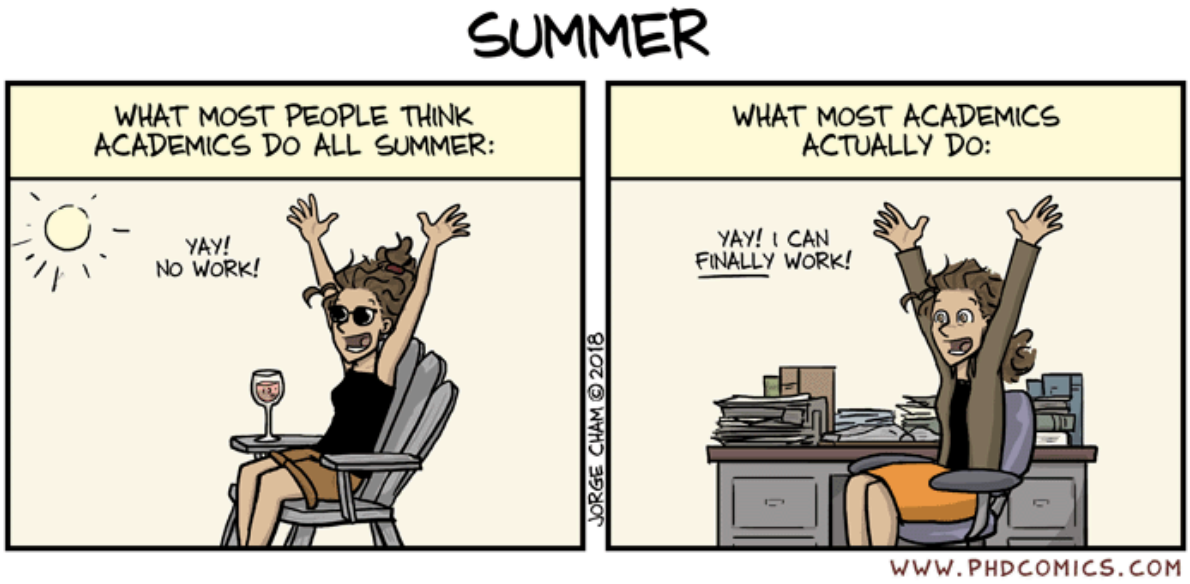
STADIUS
Center for Dynamical Systems, Signal Processing and Data Analytics

STADIUS Newsletter

June 2024

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

Welcome to the June edition of the STADIUS Newsletter! Enjoy the Summer!



Research of the month by Yingyi Chen

"Understanding self-attention and its extension to uncertainty awareness through asymmetric kernel SVD"
Work under the supervision of Johan Suykens

Recently, a new line of works has emerged to understand and improve self-attention in Transformers by treating it as a kernel machine. However, existing works apply the methods for symmetric kernels to the asymmetric self-attention, resulting in a nontrivial gap between the analytical understanding and numerical implementation. In this work, we provide a new perspective to represent and optimize self-attention through asymmetric Kernel Singular Value Decomposition (KSVD), which is also motivated by the low-rank property of self-attention normally observed in deep layers. Through asymmetric KSVD, i) a primal-dual representation of self-attention is formulated, where the optimization objective is cast to maximize the projection variances in the attention outputs; ii) a novel attention mechanism, i.e., **Primal-Attention**, is proposed via the primal representation of KSVD, avoiding explicit computation of the kernel matrix in the dual; iii) with KKT conditions, we prove that the stationary solution to the KSVD optimization in Primal-Attention yields a zero-value objective. In this manner, KSVD optimization can be implemented by simply minimizing a regularization loss, so that low-rank property is promoted without extra decomposition. Numerical experiments show state-of-theart performance of our Primal-Attention with improved efficiency.

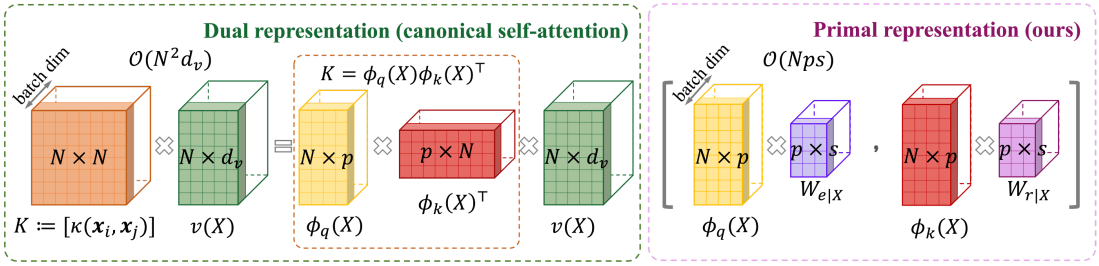
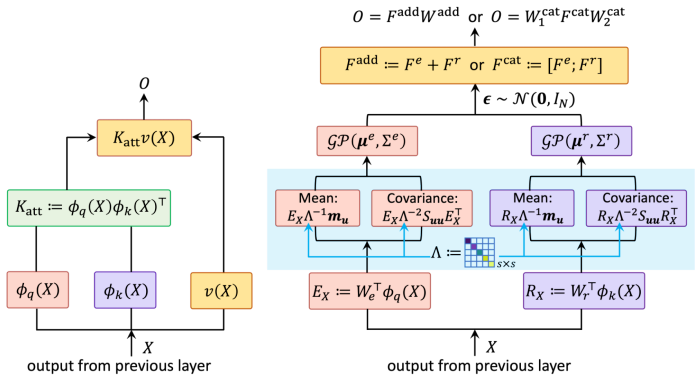


Fig 1. Primal-Attention: Self-attention through Asymmetric Kernel SVD in Primal Representation. (NeurIPS 2023)



(a) Canonical Transformer (b) KEP-SVGP

Fig 2. Self-Attention through Kernel-Eigen Pair Sparse Variational Gaussian Processes. (ICML 2024)

While the great capability of Transformers significantly boosts prediction accuracy, it could also yield over-confident predictions and require calibrated uncertainty estimation, which can be commonly tackled by Gaussian processes (GPs). Existing works apply GPs with symmetric kernels under variational inference to the attention kernel; however, omitting the fact that attention kernels are in essence asymmetric. Moreover, the complexity of deriving the GP posteriors remains high for large-scale data. In this work, we further propose Kernel-Eigen Pair Sparse Variational Gaussian Processes (**KEP-SVGP**) for building uncertaintyaware self-attention where the asymmetry of attention kernels is tackled by Kernel SVD (KSVD) and a reduced complexity is acquired. Through KEP-SVGP, i) the SVGP pair induced by the two sets of singular vectors from KSVD w.r.t. the attention kernel fully characterizes the asymmetry; ii) using only a small set of adjoint eigenfunctions from KSVD, the derivation of SVGP posteriors can be based on the inversion of a diagonal matrix containing singular values, contributing to a reduction in time complexity; iii) an evidence lower bound is derived so that variational parameters and network weights can be optimized with it. Experiments verify our excellent performances and efficiency on in-distribution, distribution-shift and out-of-distribution benchmarks.

To the best of our knowledge, this is the first work that provides a primal-dual representation for the asymmetric kernel in self-attention with carefully designed modelling and optimization, and further successfully extends it to build efficient uncertainty-aware transformers. All codes are open source on GitHub via https://github.com/yingyichen-cyy.

Links:
https://openreview.net/forum?id=bRyduWAAVT (Primal-Attention, NeurIPS 2023)
https://openreview.net/forum?id=4RqG4K5UwL (KEP-SVGP, ICML 2024)

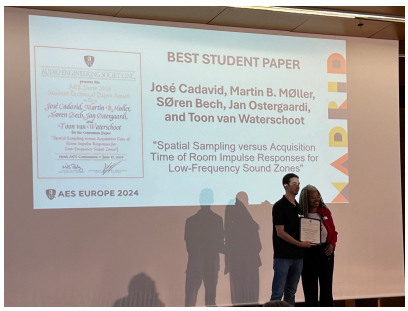
News



Alamire Foundation gets Goverment funding for the next 5,5 years

This enhanced support enables the Alamire Foundation to fully implement its ambitious new strategic plan. A key element of this plan is the **collaboration with STADIUS Center for Dynamical Systems, Signal Processing, and Data Analytics** at KU Leuven, which plays a crucial role in the Foundation's research activities.
The Alamire Foundation has received approval for substantial structural support from the Flemish Government's Department of Economy, Science Policy, and Innovation. This funding, starting in July, will be guaranteed until the end of December 2029 and presents a significant 17.33% increase compared to 2023.
The Alamire Foundation and **STADIUS are jointly involved in several important research projects.**
The Alamire Foundation's flagship projects include the Integrated Database for Early Music (IDEM), for which STADIUS has developed data mining and pattern recognition methods, and the Library of Voices, where an interactive auralization system for historical acoustics has been established.
The collaboration between Alamire Foundation and STADIUS exemplifies the integration of cutting-edge technology in preserving and studying musical heritage, demonstrating the vital role of STADIUS in Alamire's strategic plan.

Awards



Best Paper Award

We are happy to announce that the paper titled "Spatial Sampling Versus Acquisition Time of Room Impulse Responses for Low-Frequency Sound Zones" has been honored with the Student Technical Paper Award by the Audio Engineering Society (AES) at the AES Convention 2024.
Authored by **José Cadavid**, Martin B. Møller, Søren Bech, **Toon van Waterschoot**, and Jan Østergaard, this research was recognized for its outstanding contribution to the field of audio engineering.
José Cadavid, a researcher in the SOUNDS project coordinated by Toon van Waterschoot, received the award

during the 156th AES Convention in Madrid on June 17, 2024.
Congratulations to the entire team!

^

Newly approved projects

This month several project proposals were approved:

Interdisciplinary Network (IDN): *Quality improvement in inguinal hernia surgery by analysis of big data with implementation of the MDR legislation*

- Coordinator: Marc Miserez (UZ Leuven)
- STADIUS PI: **Bart De Moor** (STADIUS)
- Other Partners: Jan De Bruyne (OE Centrum voor IT & IE Recht)
- Duration: 4 years

Interdisciplinary Network (IDN): *AI-guided computational design of anti-virulence proteins as sustainable alternative antibacterials*

- Coordinator: Arnout Voet (Biochemie, Moleculaire & Struct. Biologie)
- STADIUS PI: **Yves Moreau** (STADIUS)
- Other Partners: Kristel Bernaerts (Chem.& Bioch. Reactortechn.& Veilig.), Karen Vanhoorelbeke (Chemie Kulak), Hans Steenackers (Microbiële en Plantengenetica Leuven), Emmanuel Andre (Labo voor Klinische Microbiologie)
- Duration: 4 years

Internal C1 Project: *Rethinking Transformers Through Duality Principles*

- STADIUS PIs: **Johan Suykens** (coordinator), **Panos Patrinos**
- Duration: 4 years

Internal C3 Project: *NEONAID: Neonatal Online Neuro-Analysis for Interpretation and Decision-support - Bringing automated neonatal monitoring to the bedside.*

- Coordinator: **Maarten De Vos**
- Other Partners: Gunnar Naulaers (Vrouw en Kind), Katrien Jansen (Locomotorische en Neurologische Aand), Anneleen Dereymaeker (Vrouw en Kind)
- Duration: 2 years

Congratulations to the successful teams.

Events @ STADIUS

Meet the jury symposium "*Overcoming distributional shifts in federated learning and applications in biomedicine*"
When: **05/07/2024, 10:30**
Where: **B91.200**
By: **Gamze Gürsoy**

PhD defense - Melanie Nijs: "Non-negative Matrix Factorization for the Analysis of Mass Spectrometry Imaging Data - with applications to other omics modalities"
When: **05/07/2024, 14:00**
Where: **Aula van de Tweede Hoofdwet** - Thermotechnisch Instituut

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!



Hi everyone,

My name is **Alejandro Jaramillo Rodriguez** I have a BSc in Astronomy from the University of Antioquia in Colombia, after graduating I decided to make a career change and I joined the MSc in Music and Acoustic Engineering at Politecnico di Milano. Almost three years later I'm very happy with that decision and now I'm happy to start my PhD here at KU Leuven under the supervision of Prof. Toon Van Waterschoot.
During my stay at KU Leuven I will be working on developing signal processing and AI methods for wildlife monitoring. Specifically, we will be working with distributed networks of microphone arrays that can be used for detecting, counting and localizing bioacoustical sources.
In my free time I usually play the guitar or watch some series. I love music, nature, and visiting new places.

Looking forward to meeting you all!

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

Best of luck!

This month, two colleagues are leaving STADIUS, and we wish them all the best on their new career paths:

- **Melanie Nijs,** a researcher supervised by Bart De Moor, who is having her public PhD defense on 05/07
- **Fan He,** a postdoctoral researcher who worked in the group of Johan Suykens for the past year.

Good luck with your careers!

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.

24-90

He F., He M., Shi L., Huang X., Suykens J.A.K., ``Learning Analysis of Kernel Ridgeless Regression with Asymmetric Kernel Learning'', Technical Report 24-90, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2024.

24-91

Roebben A., van Waterschoot T., Moonen M., ``Cascaded noise reduction and acoustic echo cancellation based on an extended noise reduction'', Technical Report 24-91, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2024. Accepted for publication in *32nd European Signal Processing Conference (EUSIPCO)*.
Lirias number: 4164243.

24-92

Ketcham R., Pollin S., Moonen M., ``Optimal Time-Switching for MU MISO SWIPT employing OFDM with Power Harvesting Constraints'', Technical Report 24-92, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2024.

24-94

Sillis L., Foulon V., Allegaert K., Bogaerts A., De Vos M., Hompes T., Smits A., Van Calsteren K., Verbakel J., Ceulemans M., ``The BELpREG Registry on Perinatal Medication Exposure and Mother-Infant Outcomes: Preliminary Insights into this unique Pregnancy Cohort in Belgium'', *Proc. of the 2024 ISPE Annual Meeting*, Berlin, Germany, Aug. 2024, 1 p.
Lirias number: 4163612.

24-95

Deferm W., Singh B., Wass S., De Vos M., Van den Bergh B., De Bruyn S., Wouters E., Ponnet K., Boets B., ``Objectively quantifying micro self- and co-regulation dynamics in a cohort of dysregulated children and families enrolled in an intensive intervention program.'', *Proc. of the WAIMH 2024 Interim World Congress*,

Tampere, Finland, Jun. 2024, 1 p.
Lirias number: 4162176.

24-96

Sillis L., Foulon V., Allegaert K., Bogaerts A., De Vos M., Hompes T., Smits A., Van Calsteren K., Verbakel J., Ceulemans M., ``Prevalence of periconceptional use of alcohol in Belgium: insights from the BELpREG pregnancy cohort'', *Proc. of the 6th European Conference on Preconception Health and Care*, Leuven, Belgium, Sep. 2024, 1 p.
Lirias number: 4163614.



www.esat.kuleuven.be/stadius/ - Register for this newsletter
KU Leuven, ESAT/STADIUS, Kasteelpark Arenberg 10, bus 2446, B-3001 Leuven
ida.tassens@kuleuven.be .

Update your profile - Unsubscribe