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STADIUS
Center for Dynamical Systems, Signal Processing and Data Analytics

STADIUS Newsletter

NOVEMBER 2025

I hope you enjoyed the Newcomers' Party and the reception 🎉
For those who couldn't make it—or who would like to revisit the talks—the presentations are available here.

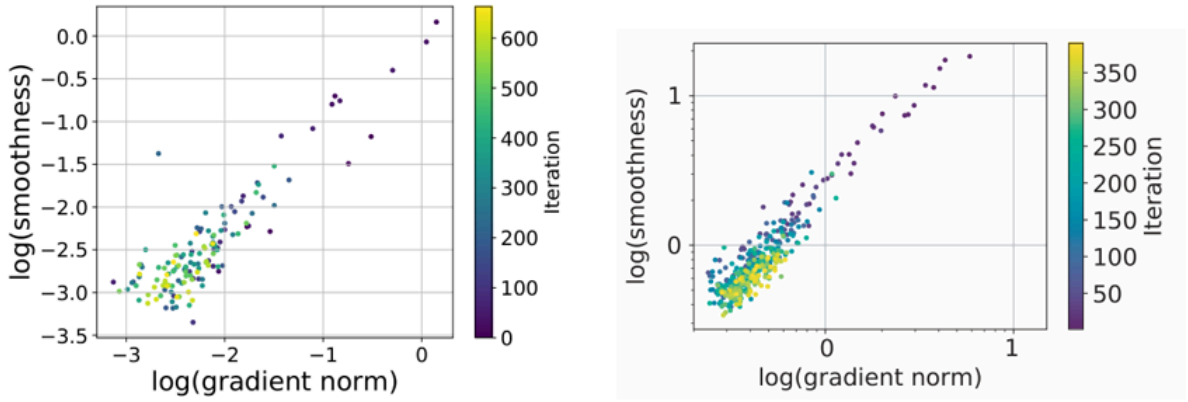
And with December approaching, don't miss our **Christmas Tree Reception on 12/12 at 16:30** in the coffee corner 🎄 ✨ !

Scroll down for more news and updates.

Research of the month by Kostas Oikonomidis, Alexander Bodard, and Jan Quan

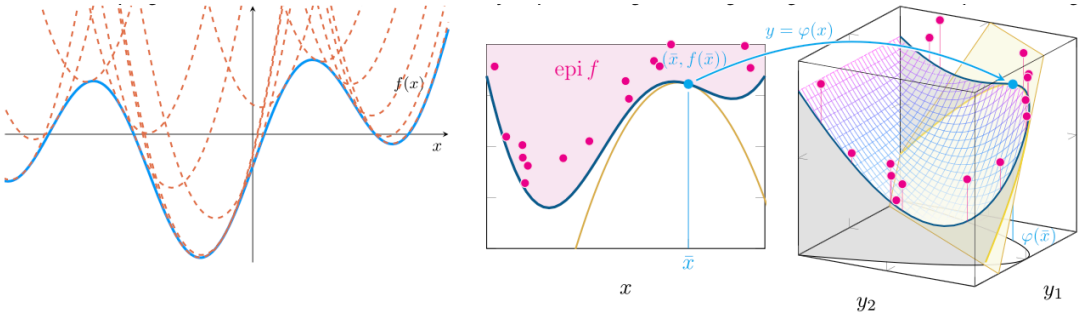
"Nonlinearly preconditioned gradient methods under generalized smoothness"
Work under the supervision of Panos Patrinos

In recent years, large language models have become an indispensable part of our daily lives. Training these neural networks is nothing else than minimizing a high-dimensional loss function. This creates challenges that can only be addressed by studying optimization algorithms in more depth. However, there is a significant gap between theory and practice, and as such, existing theory provides limited insights to practitioners. They, in turn, often resort to heuristic approaches. Our research addresses this issue by developing a flexible theoretical framework that remains close to current practice, and naturally suggests novel optimization algorithms tailored to the problem. Although motivated by neural networks, our approach also applies to a wide range of problems in signal processing, machine learning, and control.
A central issue is that classical analyses of first-order optimization methods, such as gradient descent, rely on a so-called Lipschitz smoothness assumption. However, for neural network training, it has been empirically observed not to hold (see figure). To bridge this gap, several generalized smoothness conditions have been proposed, under which the convergence of popular optimizers has been revisited. However, existing approaches typically retrofit theory to align with popular heuristics, resulting in analyses that are often tedious and unintuitive.



[Source: J. Zhang, T. He, S. Sra, and A. Jadbabaie. Why gradient clipping accelerates training: A theoretical justification for adaptivity, Feb. 2020.]

On the other hand, our work introduces a novel framework for generalized smoothness grounded in the fundamental mathematical notion of generalized convexity.This viewpoint naturally leads to a nonlinearly preconditioned variant of gradient descent that subsumes a wide range of popular optimization methods, including gradient clipping and Adam. Importantly, it also yields novel insights, and systematically generates new optimization algorithms tailored to broader classes of problems. In particular, our generalized smoothness assumption captures the behavior of loss functions arising in key applications, such as matrix factorization, phase retrieval, and Burer–Monteiro relaxations of MaxCut semidefinite programs. Moreover, our streamlined analysis provides tight convergence guarantees that surpass existing results.



To handle truly large-scale problems, we extend our analysis to the stochastic setting, where one works with minibatch gradients instead of full gradients. Here, we relax standard assumptions about gradient noise and introduce new conditions that more accurately reflect what happens in neural network training. We also extend heavy-ball momentum, a key component of optimizers like SGD and Adam, showing how it can further accelerate our methods and reduce variance. Finally, using techniques from dynamical systems, we show that nonlinear preconditioning (including approaches like gradient clipping) preserves an important geometric property of gradient descent: its tendency to avoid saddle points. Unlike classical analyses, our results apply under assumptions that are actually satisfied in modern applications. We also study a perturbed variant of our method that efficiently reaches second-order stationary points, with only logarithmic dependence on dimension, thus matching the best-known guarantees for classical algorithms.

For more detailed reading:
👉 Generalized smoothness and nonlinearly preconditioned gradient descent (Math. Program.)
https://link.springer.com/article/10.1007/s10107-025-02204-5
👉 Further properties of generalized smoothness and connections to popular optimizers (ICML oral)
https://openreview.net/forum?id=kV8oUyjdIg
👉 Momentum and stochastic analysis (NeurIPS poster)
https://openreview.net/forum?id=xGmS1i0pDq
👉 Applications and saddle point avoidance (NeurIPS spotlight)
https://openreview.net/forum?id=7qrhHzZpTA

Awards

Nokia Bell Scientific Award 2025



We are happy to invite you to the Nokia Bell Scientific Award 2025 event on Tuesday December 16 to honour the laureate, **Elisabeth Heremans** from KU Leuven, STADIUS, with her PhD entitled "Automated sleep analysis: from the hospital to the home environment."
This work was supervised by Maarten De Vos and co-supervised by Wim Van Paesschen.
Every year Nokia Belgium awards a PhD to promote ICT research and stimulate interaction between the academic and industry community.
Please join us for an exciting program where KU Leuven and Nokia Bell Labs experts will share their latest research findings.

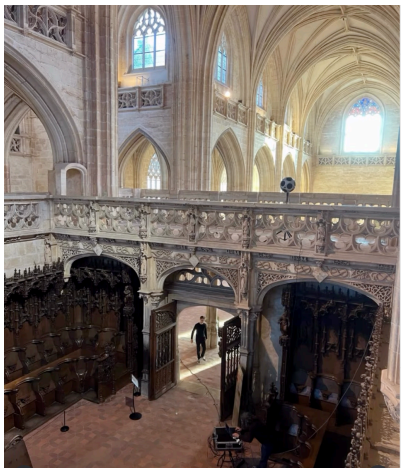


The event will take place in Antwerp (Copernicuslaan 50, 2018 Antwerp, next to the Antwerpen-Centraal railway station)

Register here

News

ESAT-STADIUS & Alamire Foundation Featured in FWO's "20 of 25"



The Research Foundation – Flanders (FWO) has placed our interdisciplinary collaboration between **STADIUS** (KU Leuven Audio Engineering Lab) and the **Alamire Foundation** in the spotlight in its "**20 of 25**" countdown.
This series highlights twenty remarkable snapshots of FWO-funded research from the past year. It opens with a photo by **Prof. Toon van Waterschoot** taken during acoustic measurements in the Cathedral of the **Monastère Royal de Brou**.
The research is part of an interdisciplinary consortium involving musicologists, historians, and engineers, aimed at understanding how acoustic environments shape the performance of early music.
Visit the post on Instagram

Professor Bart De Moor featured in De Bestuurder Visie & Strategie



Professor **Bart De Moor** (Department of Electrical Engineering, KU Leuven) is featured in the recent article *"Veel raden van bestuur beslissen nog te vaak op buiksgevoel"* ("*Many Boards Still Rely Too Much on Gut Feeling*") **De Bestuurder Visie & Strategie**.
The piece highlights his distinctive approach to governance, combining analytical rigor with empathy. It traces his journey

from AI and machine learning research to extensive experience in policy advice, entrepreneurship, and board leadership.
De Moor shares his vision of effective governance in a rapidly evolving technological landscape, emphasizing data-driven decision-making, understanding organizational ecosystems, and the importance of empathy. The article also showcases his leadership roles in Flemish AI initiatives, including the KU Leuven AI Institute, Flanders AI Academy, and Athumi, illustrating how he bridges science, technology, and human-centered management.
Read more

Structured Learning About AI: VAIA Shows the Way

In their book *AI Will Replace You: A Framework for Leaders in Times of Agentic AI*, Maarten Verschuere and Paul Joustra capture the value of the Vlaamse AI Academie (VAIA):
"In Belgium, we hit the lottery with VAIA… Instead of wandering around the internet like a lost tourist asking strangers for directions to 'good AI knowledge', you get a curated menu of everything from 'AI in Sales' to 'Data Science and AI for Energy Engineers'. The beauty of structured learning is that someone else has done the hard work figuring out what you need to know—and in what order." (p. 69)
Under the leadership of **Prof. Bart De Moor, Chairman of VAIA**, the academy provides a clear, reliable overview of AI training in Belgium, helping citizens and professionals upskill efficiently and confidently.

IEEE Honors KU Leuven's Role in Global Encryption Standard



IEEE has awarded an **IEEE Milestone** to the **Advanced Encryption Standard (AES)**, originally developed at KU Leuven by Vincent Rijmen and Joan Daemen. AES, based on their Rijndael algorithm, has become the **global encryption standard**, securing everything from internet traffic and smartphones to banking systems, cloud services, and critical infrastructure.
Selected by NIST in 2000 and standardized in 2001, AES is now embedded in nearly all modern processors and underpins key security protocols such as HTTPS, TLS, IPSec, 5G and WPA3. Professor Vincent Rijmen calls the recognition "a great honor" and a testament to how fundamental research can drive lasting societal impact.

The **bronze IEEE Milestone plaque** has been installed at the Kasteel van Arenberg in Heverlee, where the foundational ideas behind Rijndael and AES were developed.

Events @ STADIUS

PhD Defense – Brecht Evens: *"Splitting Methods for Nonmonotone Inclusion Problems"*

For more information about STADIUS events please visit the

When: 01/12/2025; 16:15
Location: Aula Arenbergkasteel
Promotor: Panos Patrinos

Master-Assisted Distributed Uplink Operation For Cell-Free Massive MIMO Networks
Speaker: Andreas Angelou
When: 03/12/2025; 11:00
Location: B00.35

PhD Defense – Jesper Brunnström: *"Sound field estimation and control over continuous regions"*
When: 04/12/2025; 13:30
Location: Auditorium C (B91.300)
Promotor: Marc Moonen
Co-Promotors: Toon van Waterschoot, Jan Østergaard

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,

I'm Arwen Mannaert. I recently graduated with a Master's degree in Electrical Engineering from KU Leuven, and I've now started an industrial PhD under the supervision of Prof. Marc Moonen in collaboration with NSX. In my research, I focus on developing a modular software infrastructure, based on Normalized Systems Theory, for the design and simulation of integrated DSP systems, applied to hearing instruments. In my free time, I enjoy cycling, running, and spending time with family and friends.
I'm excited to be part of the team and look forward to meeting you all!

Arwen



Hi,

My name is Axel Engelbosch. I recently graduated from KU Leuven with a Master of Engineering in Computer Science. For my master's thesis, I focused on segmenting vessels in images of the retina, with Professor Maarten De Vos as my co-supervisor. I am excited to continue this collaboration as I begin an interdisciplinary PhD in the BIOMED research group on the topic of machine learning for ophthalmology, with a focus on glaucoma. Outside of work, you can find me playing sports (indoor soccer, gym, …) and I occasionally also like to play video games with friends.

Axel



Hi everyone,

I'm Benedetta Perrone. I recently completed my Master's in Biomedical Engineering at Politecnico di Torino, and I've just started my PhD at STADIUS this November. My research focuses on signal processing methods for brain–computer interfaces that decode auditory attention from EEG in natural listening environments. Outside of work, I enjoy outdoor activities, listening to music, travelling, and spending time with friends. I'm very happy to join the team and look forward to meeting you all!

Benedetta



Hi all!
I'm Pablo Sánchez. I just graduated from KU Leuven's Advanced Master in AI, following my bachelor's studies in Data Science back in my hometown of Valencia, Spain. I am starting my PhD under the supervision of Prof. Johan Suykens. In our research, we focus on reconceptualising deep learning concepts through robust mathematical connections with other frameworks. Particularly, we are building upon the problem of Canonical Correlation Analysis and its Deep and Kernel variants with tensor formulations, which naturally extend to exciting subfields such as Self-Supervised Learning and Generative Models! Beyond academic life, I enjoy practising any kind of sport (preferably team sports), cooking, meditating, meeting with friends, and reading. Really excited for the path ahead and getting to know the rest of the team!
See you around!
Pablo

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

Best of luck!

- **Andreas Devogel**, researcher from Lieven De Lathauwer's group is now working as data analyst at UZ Leuven, in Management Information Reporting Unit.

Recently defended PhDs

Congratulations to the new PhD graduates!

- **27/11/2025 – Paul Didier** "Distributed Algorithms for Noise Reduction in Wireless Acoustic Sensor Networks" **Thesis**

  Promotor: Marc Moonen,
  Co-Promotors: Toon van Waterschoot, Simon Doclo

- **28/11/2025 – Miguel Bhagubai** "*AI-based Decision Support for Epilepsy Monitoring.* **Thesis**

Promotor: Maarten De Vos

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.

25-166
Baeriswyl C., Waldmann F., Bertrand A., Wildhaber R., ``Multi-Resolution Autonomous Linear State Space Filters for N-Dimensional Signals", Technical Report 25-166, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in *IEEE Transactions on Signal Processing*. Lirias number: 4271649.

25-168
van der Schaft A., Sepulchre R., Chaffey T., ``Symmetry in linear physical systems", Technical Report 25-168, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in /emph{Systems and Control Letters}, 2025. Lirias number: 4277049.

25-169
Huo Y., Chaffey T., Sepulchre R., ``Kernel Modelling of Fading Memory Systems", Technical Report 25-169, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in *IEEE Transactions in Automatic Control*, 2025. Lirias number: 4277050.

25-170
Sepulchre R., Cecconi A., Bin M., Marconi L., ``Regulation without calibration", Technical Report 25-170, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in *IEEE Control Systems*, 2025. Lirias number: 4277052.

25-171
Wang R., *Embedded Learning and Optimization for Interaction-Aware Model Predictive Control*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Nov. 2025 Lirias number: 4262428.

25-172
Heintz N., *Fast and Adaptive Auditory Attention Decoding with application in neurosteered hearing devices*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Nov. 2025 Lirias number: 4271978.

25-173
Martel M.E., Jose-Garcia A., Vens C., De Vos M., Sobanski V., ``Artificial intelligence for precision medicine", Technical Report 25-173, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in *Therapie*, 2025. Lirias number: 4273257.

25-174
Lalli G., Collier J., Moreau Y., Raimondi D., ``JINet : easy and secure private data analysis for everyone" Lirias number: 4271903.

25-175
Roebben A., van Waterschoot T., Wouters J., Moonen M., ``Identifiability Conditions for Acoustic Feedback Cancellation with the Two-Channel Adaptive Feedback Canceller Algorithm", Technical Report 25-175, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025.

25-176
Sharma M., Van Rompaey R., Lanneer W., Moonen M., ``A generalized weighted overlap-add (WOLA) filter bank for improved subband system identification", *IEEE Transactions on Signal Processing*, vol. 73, 2025, pp. 4155-4169. Lirias number: 4277252.

25-177
Chuma A.T., Kassie D.M., Voigt J.U., Asmare M.H., Youssef A.S., Varon C., Willems R., Yates M., Sikamo A.P., Birhan Y.A., Wang C., Vanrumste B., ``Prevalence of early rheumatic heart disease among asymptomatic schoolchildren in Ethiopia", Technical Report 25-177, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025.

25-178

Musaeus C.S., Viana P.F., Cook M., Duun-Henriksen J., Beniczky S., Kidmose P., Vanrumste B., Filtjens B., Wesenberg Kjaer T., ``Home-based sensing of the nervous system with clinical neurophysiology technologies : IFCN handbook chapter'', *Clinical Neurophysiology Practice*, vol. 10, 2025, pp. 453-463. Lirias number: 4272035.

25-179

Shang M., Dedeyne L., Dupont J., Vercauteren L., Amini N., Lapauw L., Gielen E., Verschueren S., Varon C., De Raedt W., Vanrumste B., ``A masked multi-task learning approach for otago micro labels recognition'', *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 33, 2025, pp. 4196-4205. Lirias number: 4274321.

25-180

Xu W., Wang C., Shang M., De Bleeker C., Torres Vega M., Vanrenterghem J., Vanrumste B., ``AI-assisted automatic jump detection and height estimation in volleyball using a waist-worn IMU'', Technical Report 25-180, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in *47th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. Lirias number: 4274855.

25-181

Wroblowski R., Sepulchre R., ``Describing Functions and Phase Response Curves of Excitable Systems'', Technical Report 25-181, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025.

25-182

Quan J., Bodard A., Oikonomidis K., Patrinos P., ``Scaled relative graphs for pairs of operators beyond classical monotonicity'', Technical Report 25-182, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025.

25-183

Oikonomidis K., Bodard A., Quan J., Patrinos P., ``Nonlinearly preconditioned gradient flows'', Technical Report 25-183, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025.

25-184

Garafalo G., Geysels A., Timmerman D., Froyman W., De Moor B., Timmerman S., Ceusters J., Valentin L., Bourne T., Blaschko M., Testa A., Van Calster B., ``ADNEX-AI : Automated extraction of ultrasound predictors for interpretable ovarian cancer risk stratification'', Technical Report 25-184, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2025. Accepted for publication in *npj Precision Oncology*. Lirias number: 4278446.

25-185

Didier P., *Distributed algorithms for noise reduction in wireless acoustic sensor networks*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Nov. 2025 Lirias number: 4266640.

25-186

Bhagubai M., *AI based decision support for epilepsy monitoring*, PhD thesis, Faculty of Engineering, KU Leuven (Leuven, Belgium), Nov. 2025 Lirias number: 4270032.



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