Tianyi Liu (刘添翼) | Dr.-Ing.

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Nationality: Chinese (eligible to work in EU – EU long-term residence issued by Germany)

Profile

- Current Postdoc and PhD graduate in Electrical Engineering.
- Solid knowledge in signal processing, matrix analysis, and optimization theory.
- Proficiency in optimization methods for estimation in signal processing and communications.
- Excellent technical writing skills with 1 book section and 4 journal articles submitted.
- Proven communication and presentation skills fluently in English.

Education

Technical University of Darmstadt **Darmstadt, Germany**
Dr.-Ing. in Elect. Eng. and Inform. Technol., with distinction *Oct. 2018 – Sept. 2024*
Advisor: Prof. Marius Pesavento, Co-referee: Prof. Stefan Ulbrich
Committee members: Prof. Abdelhak M. Zoubir, Prof. Sebastian Schöps, and Prof. Mario Kupnik

Technical University of Darmstadt **Darmstadt, Germany**
M.Sc. in Elect. Eng. and Inform. Technol., with distinction *Oct. 2016 – July 2018*
Recipient of the Best Master Student Award from the Dept. ETIT.
Master Thesis: *A scalable graph-based mixed-integer linear programming approach for the examination timetabling problem.*

Politecnico di Torino **Turin, Italy**
M.Sc. in Communications and Computer Networks Eng., with distinction *Sept. 2015 – July 2018*

Politecnico di Torino **Turin, Italy**
B.Sc. in Telecommunications Engineering *Sept. 2014 – July 2015*

Tongji University **Shanghai, China**
B.Eng. in Electronics and Information Engineering *Sept. 2011 – June 2015*

Research Interests

- Sparse signal processing
- Parallel optimization methods: Focusing on nonconvex and nonsmooth problems
- Sensor array signal processing: Direction-of-Arrival estimation
- Graph signal processing: Graph topology inference
- Game theory: Generalized Nash equilibrium

Work Experience

Communication Systems Group, TU Darmstadt **Darmstadt, Germany**
Doctoral and Postdoctoral Research Associate *2018 – 2025*

- PhD Thesis: *A parallel successive convex approximation framework with smoothing majorization for phase retrieval.* Developed a novel parallelizable algorithmic framework based on majorization-minimization (MM) and successive convex approximation (SCA) for a broad class of nonconvex and nonsmooth optimization

problems. The main idea is to solve a difficult problem by converting it into a sequence of simpler surrogate problems. It provides the provable convergence to a generalized stationary point. As applications, I employed this algorithmic framework to efficiently address the phase retrieval with dictionary learning problem arising in X-ray diffraction imaging and joint channel estimation and signal detection in MIMO communication systems.

- Collaborative projects on separating signals of different frequencies from their mixtures with sparsity techniques, with application to direction-of-arrival (DOA) estimation using distributed passive sensor arrays.
- Other research works on graphical model learning from real-world data, including meteorological, traffic, financial, and biological data.
- Supervised student projects on analyzing the performance of the GPU implementation with CUDA of the parallel algorithms.
- Programming experiences: Most of the simulations are implemented in MATLAB, C++, or Python, and conducted on Linux-based high-performance computing clusters. Neural networks with PyTorch.
- Co-authored 1 book section, 4 internationally refereed journal articles. Presented my research at 8 international conferences in different countries.

Politecnico di Torino **Turin, Italy**
Research Assistant *Mar. 2015 – July 2015*
Developed a heuristic algorithm for optimizing constellation in satellite communication. Implemented in C++.

Teaching Experience

Communication Systems Group, TU Darmstadt **Darmstadt, Germany**
Teaching Assistant *2018 – present*
Prepared and delivered tutorials in fundamental and advanced courses on matrix analysis, optimization theory, MIMO communications, graph signal processing, and machine learning. Supervised 15 individual student projects.

Professional Skills

Signal Processing and Communications: Sparse signal processing/Compressed sensing, Dictionary learning/Sparse coding, Sensor array and statistical signal processing, Source localization/Radar, Direction-of-arrival (DOA) estimation, Beamforming, MIMO communications, Coherent diffraction imaging, Image processing, Graph signal processing, Graph topology learning, Machine learning (Graphical models, Neural networks, Graph neural networks)

Optimization and Mathematics: Parallel and sparse optimization methods, Least-squares and regularized least-squares, Nonlinear programming, Mixed-integer programming (MIP), Matrix analysis, Convex analysis, Graph theory, Probability theory

Programming: MATLAB, Python/Numpy/PyTorch, C/C++, Julia, Linux, Bash/Zsh, Git, CUDA

Optimization Tools: CVX, MOSEK, Gurobi, SCIP/SCIP-SDP, CPLEX

Writing and Note Management: Markdown, LaTeX, Obsidian, Zotero, PARA method, Neovim

Languages: Chinese (mother tongue), English (fluent), German (intermediate), Italian (intermediate)

Honors and Awards

Finalist of the IEEE SAM 2024 Best Student Paper Contest *2024*
IEEE SPS Student Travel Grant for the IEEE CAMSAP 2019 *2019*
Finalist of the EUSIPCO 2019 Best Student Paper Contest *2019*
Best Master Student Award from Dept. ETIT, TU Darmstadt *2018*
Erasmus+ Mobility Program Scholarship *2016–2018*
Full Scholarship from EDISU Piemonte, Italy *2015–2018*

Participated Projects

- German Research Foundation (DFG), "The partial relaxation method in direction-of-arrival estimation: Design and analysis", PI: Prof. Marius Pesavento, €300K, 2019–2025
- DFG priority program on Compressed Sensing in Information Processing (CoSIP), "Exploiting structure in compressed sensing using side constraints: From analysis to system design – Funding phase II", PI: Prof. Martin Haardt, Prof. Marc Pfetsch, Prof. Marius Pesavento, €300K for each group, 2018–2021

Professional Skills Training

Attendance at the IEE-SPS/EURASIP Summer School on Network- and Data-Driven Learning 2019

Academic Service

Reviewer for *Elsevier Signal Processing* and *IEEE Signal Processing Letters*.

Referees

Prof. Marius Pesavento: Communication Systems Group, TU Darmstadt, Germany
Email: pesavento@nt.tu-darmstadt.de Phone: +49 (0)6151 16-20342

Prof. Martin Haardt: Communications Research Laboratory, TU Ilmenau, Germany
Email: martin.haardt@tu-ilmenau.de Phone: +49 (0)3677 69-2613

Prof. Marc Pfetsch: Optimization and Operations Research, TU Darmstadt, Germany
Email: pfetsch@mathematik.tu-darmstadt.de Phone: +49 (0)6151 16-23440

Appendix

Conferences & Workshops

Oregon, USA *July 2024*
IEEE 13th Sensor Array and Multichannel Signal Processing Workshop (SAM)
Finalist of the Best Student Paper Contest

Seoul, Korea, Republic of *April 2024*
IEEE 49th International Conference on Acoustics, Speech, and Signal Processing (ICASSP)

Herradura, Costa Rica *Dec. 2023*
IEEE 9th International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)

Helsinki, Finland *Sept. 2023*
31st European Signal Processing Conference (EUSIPCO)

Toronto, Canada *June 2021*
IEEE 46th International Conference on Acoustics, Speech, and Signal Processing (ICASSP)

Hangzhou, China *June 2020*
IEEE 11th Sensor Array and Multichannel Signal Processing Workshop (SAM)

Guadeloupe, West Indies *Dec. 2019*
IEEE 8th International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)
IEEE SPS Student Travel Grant

A Coruña, Spain *Sept. 2019*
27th European Signal Processing Conference (EUSIPCO)
Finalist of the Best Student Paper Contest

Publications

Theses

[T1] **T. Liu**, "A parallel successive convex approximation framework with smoothing majorization for phase retrieval," Ph.D. dissertation, Technische Universität Darmstadt, Darmstadt, Oct. 2024. DOI: 10.26083/tuprints-00028201

[T2] **T. Liu**, "A scalable graph-based mixed-integer linear programming approach for the examination timetabling problem," M.S. thesis, Politecnico di Torino, Turin, Jul. 2018.

Book Chapters

[B1] K. Ardah, M. Haardt, **T. Liu**, F. Matter, M. Pesavento, and M. E. Pfetsch, "Recovery under side constraints," in *Compressed sensing in information processing*, G. Kutyniok, H. Rauhut, and R. J. Kunsch, Eds., Cham: Springer International Publishing, 2022, pp. 213–246, ISBN: 978-3-031-09745-4.

Preprints

[P1] **T. Liu**, S. P. Deram, K. Ardah, M. Haardt, M. E. Pfetsch, and M. Pesavento, *Gridless parameter estimation in partly calibrated rectangular arrays*, Jun. 2024. DOI: 10.48550/arXiv.2406.16041 arXiv: 2406.16041 [eess].

[P2] **T. Liu**, F. Matter, A. Sorg, M. E. Pfetsch, M. Haardt, and M. Pesavento, *Maximum a posteriori direction-of-arrival estimation via mixed-integer semidefinite programming*, Oct. 2024. DOI: 10.48550/arXiv.2311.03501 arXiv: 2311.03501.

Journal Articles

[J1] R. Müller, G. Allevato, M. Rutsch, C. Haugwitz, **T. Liu**, M. Kupnik, and M. Pesavento, "A tensor model for the calibration of air-coupled ultrasonic sensor arrays in 3D imaging," *Signal Processing*, p. 109 812, Nov. 2024, ISSN: 0165-1684. DOI: 10.1016/j.sigpro.2024.109812

[J2] **T. Liu**, A. M. Tillmann, Y. Yang, Y. C. Eldar, and M. Pesavento, "Extended successive convex approximation for phase retrieval with dictionary learning," *IEEE Transactions on Signal Processing*, vol. 70, pp. 6300–6315, 2022, ISSN: 1941-0476. DOI: 10.1109/TSP.2022.3233253

Conference Proceedings

[C1] **T. Liu**, S. P. Deram, K. Ardah, M. Haardt, M. E. Pfetsch, and M. Pesavento, "Gridless parameter estimation in partly calibrated rectangular arrays," in *ICASSP 2024 - 2024 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Apr. 2024, pp. 8796–8800. DOI: 10.1109/ICASSP48485.2024.10446959

[C2] **T. Liu** and M. Pesavento, "Blind phase-offset estimation in sparse partly calibrated arrays," in *2024 IEEE 13rd Sensor Array and Multichannel Signal Processing Workshop (SAM)*, Jul. 2024, pp. 1–5. DOI: 10.1109/SAM60225.2024.10636507

[C3] **T. Liu**, F. Matter, A. Sorg, M. E. Pfetsch, M. Haardt, and M. Pesavento, "Joint sparse estimation with cardinality constraint via mixed-integer semidefinite programming," in *2023 IEEE 9th International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)*, Herradura, Costa Rica, Dec. 2023, pp. 106–110. DOI: 10.1109/CAMSAP58249.2023.10403415

[C4] Y. Zhang, **T. Liu**, and M. Pesavento, "Direction-of-arrival estimation for correlated sources and low sample size," in *2023 31st European Signal Processing Conference (EUSIPCO)*, Sep. 2023, pp. 1559–1563. DOI: 10.23919/EUSIPCO58844.2023.10290019

[C5] **T. Liu**, A. M. Tillmann, Y. Yang, Y. C. Eldar, and M. Pesavento, "A parallel algorithm for phase retrieval with dictionary learning," in *IEEE International Conference on Acoustics, Speech and Signal Processing*, Jun. 2021, pp. 5619–5623. DOI: 10.1109/ICASSP39728.2021.9413991

[C6] X. Wang, **T. Liu**, M. Trinh-Hoang, and M. Pesavento, "GPU-accelerated parallel optimization for sparse regularization," in *2020 IEEE 11th Sensor Array and Multichannel Signal Processing Workshop (SAM)*, Jun. 2020, pp. 1–5. DOI: 10.1109/SAM48682.2020.9104328

[C7] **T. Liu**, M. Trinh-Hoang, Y. Yang, and M. Pesavento, "A block coordinate descent algorithm for sparse Gaussian graphical model inference with laplacian constraints," in *IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing*, Dec. 2019, pp. 236–240. DOI: 10.1109/CAMSAP45676.2019.9022643

[C8] **T. Liu**, M. Trinh-Hoang, Y. Yang, and M. Pesavento, "A parallel optimization approach on the infinity norm minimization problem," in *2019 27th European Signal Processing Conference (EUSIPCO)*, A Coruna, Spain: IEEE, Sep. 2019, pp. 1–5, ISBN: 978-90-827970-3-9. DOI: 10.23919/EUSIPCO.2019.8902548

Teaching Assistant at TU Darmstadt

Courses

18-pe-2080 Graph Signal Processing, Learning and Optimization
Instructor: Prof. Marius Pesavento — *WS 2020/21 – WS 2024/25*

18-pe-2070 Matrix Analysis and Computations
Instructor: Prof. Marius Pesavento — *SS 2019 – SS 2024*

18-pe-2050 Project Seminar: Procedures for Massive MIMO and 5G
Instructor: Prof. Marius Pesavento — *SS 2020*

18-pe-2030 MIMO Communication and Space-Time Coding
Instructor: Prof. Marius Pesavento — *WS 2018/19 – WS 2019/20*

Supervised Student Projects

[S1] A. Ahmad, "Distributed nonlinear polynomial graph filter and its output graph spectrum," Project seminar, Technische Universität Darmstadt, Darmstadt, Dec. 2022.

[S2] A. Sorg, "Direction of arrival estimation in the multiple measurement model using sparse reconstruction," M.S. thesis, Technische Universität Darmstadt, Darmstadt, Nov. 2022.

[S3] Y. Zhang, "Advanced optimization methods for direction-of-arrival estimation with correlated sources," M.S. thesis, Technische Universität Darmstadt, Darmstadt, Mar. 2022.

[S4] S. Rajurkar, "Resource allocation in wireless networks using graph convolutional neural networks," M.S. thesis, Technische Universität Darmstadt, Darmstadt, Nov. 2021.

[S5] H. S. Saka, "Sparse graph Laplacian learning with real-world data," Bachelor thesis, Technische Universität Darmstadt, Darmstadt, Apr. 2021.

[S6] Y. Zhang, "Sparse graph Laplacian learning with real-world data," M.S. thesis, Technische Universität Darmstadt, Darmstadt, May 2021.

[S7] S. Ben Abid, "Parallel optimization methods for graph topology learning and tracking," Bachelor thesis, Technische Universität Darmstadt, Darmstadt, Mar. 2020.

[S8] F. Bonakdar, "Sparse reconstruction and prediction of mobility patterns in traffic networks," M.S. thesis, Technische Universität Darmstadt, Darmstadt, Jun. 2020.

[S9] M. Grytz, "Implementation of a block coordinate descent graph learning algorithm and its application to real-world problems," Studienarbeit, Technische Universität Darmstadt, Darmstadt, Oct. 2020.

[S10] H. S. Saka, "Optimization algorithms for graph Laplacian estimation via ADMM and MM," Project seminar, Technische Universität Darmstadt, Darmstadt, Sep. 2020.

[S11] D. Jaoua, "Parallel optimization methods for sparse signal recovery from non linear mixtures," M.S. thesis, Technische Universität Darmstadt, Darmstadt, 2019.

[S12] S. U. Rehman, “Implementation of a parallel algorithm for sparse optimization on a graphical processing unit,” M.S. thesis, Technische Universität Darmstadt, Darmstadt, Jul. 2019.

[S13] X. Wang, “Implementation of parallel optimization for nondifferentiable nonconvex problems on GPU architecture,” M.S. thesis, Technische Universität Darmstadt, Darmstadt, Sep. 2019.