

Elias S. Wirth

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CORE COMPETENCIES

Programming Languages, 4+ years of Python and 2+ years of Julia experience in algorithm development.

Research, 5+ years of research experience publishing in top convex optimization venues.

EDUCATION

2020 – 2024 **Ph.D., Mathematics**, Technische Universität Berlin (TU Berlin), Berlin, Germany.

- Thesis: Frank-Wolfe Algorithms in Polytope Settings

- Advisor: Sebastian Pokutta

2018 – 2020 **M.Sc., Mathematics**, Eidgenössische Technische Hochschule Zürich (ETH Zürich), Zurich, Switzerland.

- GPA: 5.46/6.00

- Thesis: Sum of Squares Bounds for Combinatorial Optimization Problems

- Advisors: Rico Zenklusen & Adam Kurpisz

2015 – 2018 **B.Sc., Mathematics**, Universität Bern, Berne, Switzerland.

- GPA: 5.11/6.00

- Thesis: Linear Multistep Methods

- Advisor: Thomas Wihler

EXPERIENCE

2019 **Intern**, ETH Zürich, Zurich, Switzerland.

- Interned at the IFOR, supervised by Rico Zenklusen, focusing on combinatorial optimization for industry applications.

- Performed debugging of Scala codebase, enhancing system reliability and performance.

PUBLICATIONS

JOURNAL ARTICLES AND CONFERENCE PROCEEDINGS

- Adam Kurpisz and Elias Wirth. Sum of squares bounds for the empty integral hull problem. In *Proceedings of the 2023 International Symposium on Symbolic and Algebraic Computation*, pages 443–451, 2023
- David Martínez-Rubio, Elias Wirth, and Sebastian Pokutta. Accelerated and sparse algorithms for approximate personalized pagerank and beyond. In *Proceedings of Conference on Learning Theory*, volume 195, pages 2852–2876. PMLR, 2023
- Elias Wirth, Hiroshi Kera, and Sebastian Pokutta. Approximate vanishing ideal computations at scale. In *Proceedings of the International Conference on Learning Representations*, 2023
- Elias Wirth, Thomas Kerdreux, and Sebastian Pokutta. Acceleration of Frank-Wolfe algorithms with open-loop step-sizes. In *Proceedings of the International Conference on Artificial Intelligence and Statistics*, pages 77–100. PMLR, 2023
- Elias Wirth and Sebastian Pokutta. Conditional gradients for the approximately vanishing ideal. In *Proceedings of the International Conference on Artificial Intelligence and Statistics*, pages 2191–2209. PMLR, 2022
- Adam Kurpisz, Aaron Potechin, and Elias Samuel Wirth. Sos certification for symmetric quadratic functions and its connection to constrained boolean hypercube optimization. In *Proceedings of the International Colloquium on Automata, Languages, and Programming*. Schloss Dagstuhl-Leibniz-Zentrum für Informatik, 2021

PREPRINTS

- Elias Wirth, Mathieu Besançon, and Sebastian Pokutta. The pivoting framework: Frank-Wolfe algorithms with active set size control. Manuscript in preparation, 2024
- Elias Wirth, Javier Pena, and Sebastian Pokutta. Accelerated affine-invariant convergence rates of the Frank-Wolfe algorithm with open-loop step-sizes. *arXiv preprint arXiv:2310.04096*, 2023

1. Christophe Roux, Elias Wirth, Sebastian Pokutta, and Thomas Kerdreux. Efficient online-bandit strategies for minimax learning problems. *arXiv preprint arXiv:2105.13939*, 2021

SELECTED SOFTWARE PROJECTS

Python

- 2023 **AffineInvariantOLFW**, *Python*, Relevant packages: NumPy.
- Implemented open-loop Frank-Wolfe algorithms for sparse regression, logistic regression, and low-rank matrix recovery problems in NumPy.
- 2022 **CGAVI**, *Python*, Relevant packages: CuPy, NumPy, scikit-learn.
- Developed and implemented approximate vanishing ideal algorithms in CuPy for feature transformation techniques for a linear kernel SVM from scikit-learn.
- Conducted extensive testing and developed a custom hyperparameter tuning pipeline.

Julia

- since 2024 **FrankWolfe.jl**, *Julia*, Relevant packages: FrankWolfe.
- Became a developer of the FrankWolfe package, which provides an implementation of Frank-Wolfe algorithms.
- Contributed by implementing the pairwise Frank-Wolfe algorithm and advanced open-loop step-sizes.
- 2024 **ApproximateVanishingIdeals.jl**, *Julia*, Relevant packages: FrankWolfe, LinearAlgebra.
- Guided a student project developing a Julia package based on my Python repository **CGAVI**.
- 2023 **AAPPR.jl**, *Julia*, Relevant packages: LinearAlgebra, SparseArrays, Graphs.
- Developed and implemented approximate personalized PageRank algorithms, tailored for large-scale graphs.
- Achieved breakthroughs in computational efficiency and sparsity, outperforming prior state-of-the-art solutions.
- 2022 **KernelHerding.jl**, *Julia*, Relevant packages: FrankWolfe.
- Highlighted the applicability of the FrankWolfe package to kernel herding problems in infinite dimensions.

AWARDS, HONORS, & RECOGNITIONS

- 2024 **MATH+ travel grant**, Berlin Mathematics Research Center, Berlin, Germany.
- Amount: 1200\$
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- 2022 **MATH+ travel grant**, Berlin Mathematics Research Center, Berlin, Germany.
- Amount: 1200\$
- 2022 – 2024 **MATH+ doctoral student member**, Berlin Mathematics Research Center, Berlin, Germany.
- 2013 **Best final high school thesis award**, Cantonal School Olten, Olten, Switzerland.
- Thesis: An experimental U-value comparison of window frames and glass at the Kantonsschule Olten
- Advisor: Lukas Derendinger
- Amount: 200\$
- 2012 – 2013 **Gifted student program**, *Introduction to Game Theory*, Universität Basel, Basel, Switzerland.
- Select high school students were granted the option to attend an isolated university course.

TEACHING

Teaching Assistance

- Spring 2024 **Linear Algebra II for Mathematicians**, TU Berlin, Berlin, Germany.
Fall 2023 **Introduction to Linear and Combinatorial Optimization**, TU Berlin, Berlin, Germany.
- Spring 2023 **Mathematics for Physicists IV**, TU Berlin, Berlin, Germany.
Fall 2022 **Mathematical Physics I**, TU Berlin, Berlin, Germany.
- Spring 2022 **Differential Equations for Engineers**, TU Berlin, Berlin, Germany.
Fall 2021 **Analysis I for Mathematicians**, TU Berlin, Berlin, Germany.
- Spring 2021 **Differential Equations for Engineers**, TU Berlin, Berlin, Germany.
Fall 2020 **Analysis and Linear Algebra**, TU Berlin, Berlin, Germany.
Fall 2019 **Discrete Mathematics**, ETH Zürich, Zurich, Switzerland.
- Spring 2018 **Combinatorics**, Universität Bern, Berne, Switzerland.
Fall 2017 **Statistics for Sports Sciences**, Universität Bern, Berne, Switzerland.
- Spring 2017 **Combinatorics**, Universität Bern, Berne, Switzerland.

Seminar Organization

- Spring 2023 **Discrete Optimization and Machine Learning**, TU Berlin, Berlin, Germany.
Fall 2022 **Discrete Optimization and Machine Learning**, TU Berlin, Berlin, Germany.

- Spring 2022 **Discrete Optimization and Machine Learning**, TU Berlin, Berlin, Germany.
 Fall 2021 **Discrete Optimization and Machine Learning**, TU Berlin, Berlin, Germany.
 Spring 2021 **Discrete Optimization and Machine Learning**, TU Berlin, Berlin, Germany.
 Fall 2020 **Discrete Optimization and Machine Learning**, TU Berlin, Berlin, Germany.

MENTORED STUDENTS

- since 2023 **Nico Pelleriti (B.Sc.)**, Zuse Institute Berlin (ZIB), Berlin, Germany.
 - Joint supervision with Max Zimmer.
 - Incorporating approximate vanishing ideal algorithms into deep learning pipelines.
- since 2023 **Dominik Kuzinowicz (B.Sc.)**, ZIB, Berlin, Germany.
 - Creating a package for approximate vanishing ideal algorithms in Julia.
 - Thesis: Dominik Kuzinowicz. *Approximate Vanishing Ideal Algorithms for Identification of Non-linear Dynamics*. Bachelor's thesis, Technische Universität Berlin, 2023
- 2022 – 2024 **Garam Kim (M.Sc.)**, ZIB, Berlin, Germany.
 - Worked on various topics in the Frank-Wolfe literature.
 - Thesis: Garam Kim. *Beyond Alternating Projections: Accelerated Alternating Linear Minimizations in Feasibility Problems*. Master's thesis, Technische Universität Berlin, 2023

Service

SCIENTIFIC SERVICE

- 2023 **Manuscript reviewer** for **P. Breiding, K. Kohn and B. Sturmfels**, *Metric Algebraic Geometry*.
 2022 **Session chair**, *Conditional Gradients and Machine Learning*, INFORMS Annual Meeting, Indianapolis, IN, USA.

REFEREEING

- 2023 **International Conference on Artificial Intelligence and Statistics (AISTATS)**.
 2022 **International Conference on Artificial Intelligence and Statistics (AISTATS)**.
 2022 **Journal of Combinatorial Optimization (JOCO)**.

OUTREACH & DIVERSITY

- 2024 **Volunteer organizer**, *Girl's Day*, ZIB, Berlin, Germany.
 - Public outreach event to increase interest in science in female students.
- 2022 **Volunteer organizer**, *Lange Nacht der Wissenschaften*, ZIB, Berlin, Germany.
 - Public outreach event for the Berlin science community to exhibit discoveries for the public (accessible for all ages).
- 2022 **Public lecturer**, *Tag der Mathematik*, ZIB, Berlin, Germany.
 - Public educational event on mathematics aimed at teachers and students.
- 2019 – 2020 **Board member**, *VMP*, ETH Zürich, Zurich, Switzerland.
 - Represented the student body.
 - Organized recruitment and social events for the ETH Zürich mathematics and physics students.

SELECTED PRESENTATIONS

- 07.2024 **International Symposium on Mathematical Programming**, Montréal, Canada.
 - Invited lecture: "Accelerated Affine-Invariant Convergence Rates of the Frank-Wolfe Algorithm with Open-Loop Step-Sizes"
- 08.2023 **Conference on Optimization and Machine Learning**, Tokyo, Japan.
 - Invited lecture: "The Pivoting Framework: Frank-Wolfe Algorithms with Active Set Size Control"
- 07.2023 **Conference on Learning Theory (COLT)**, Bangalore, India.
 - Invited lecture and poster: "Accelerated and Sparse Algorithms for Approximate Personalized PageRank and Beyond" (talk held by David Martínez-Rubio)
- 04.2023 **International Conference on Learning Representations (ICLR)**, Kigali, Rwanda.
 - Poster: "Approximate Vanishing Ideal Computations at Scale"
- 04.2023 **International Conference on Artificial Intelligence and Statistics (AISTATS)**, Valencia, Spain.
 - Poster: "Acceleration of Frank-Wolfe Algorithms with Open-Loop Step-Sizes"
- 03.2023 **Workshop on Optimization and Machine Learning**, Waischenfeld, Germany.
 - Invited lecture and poster: "Acceleration of Frank-Wolfe Algorithms with Open-Loop Step-Sizes"
- 10.2022 **INFORMS Annual Meeting**, Indianapolis, IN, USA.
 - Lecture in chaired session: "Acceleration of Frank-Wolfe Algorithms with Open-Loop Step-Sizes"
- 10.2022 **INFORMS Annual Meeting**, Indianapolis, IN, USA.
 - Invited lecture: "Conditional Gradients for the Approximate Vanishing Ideal"

- 09.2022 **RIKEN-IMI-ISM-ZIB-MODAL Workshop**, Tokyo, Japan.
- Invited lecture: "Conditional Gradients for the Approximate Vanishing Ideal"
- 09.2022 **POEMA**, Paris, France.
- Invited lecture: "Approximate Vanishing Ideal Algorithms" (talk held by Hiroshi Kera)
- 03.2022 **International Conference on Artificial Intelligence and Statistics (AISTATS)**, virtual conference.
- Poster: "Conditional Gradients for the Approximately Vanishing Ideal"
- 07.2021 **What is ...? Seminar**, Berlin, Germany.
- Invited lecture: "The Frank-Wolfe Algorithm"