Daniel Brosch

Curriculum Vitae

Personal Details

Date of birth	November 18, 1996
Place of birth	Leverkusen, Germany
Citizenship	German

PhD-Thesis

title	Symmetry Reduction in Convex Optimization with Applications in Combinatorics
main supervisor	*Etienne de Klerk*
co-supervisor	*Monique Laurent*
summary	We explore different approaches to and applications of symmetry reduction in convex optimization. Using tools from semidefinite programming, representation theory and algebraic combinatorics, we solve or bound hard problems coming from combinatorial optimization, energy minimization, queuing theory, and extremal combinatorics.
scheduled defense date	October 19, 2022.

Education

2018–	**PhD-candidate**, *Tilburg University*, the Netherlands Under supervision of *Etienne de Klerk* and *Monique Laurent*, as early stage researcher of the Marie-Curie innovative training network MINOA.
January 2020 – March 2020	**Secondment**, *Centrum Wiskunde & Informatica*, Amsterdam, the Netherlands
October 2019 – December 2019	**Secondment**, *Ortec*, Zoetermeer, the Netherlands
2017–2018	**Mathematics MSc**, *University of Cologne*, *cum laude* Thesis: *Semidefinite Bounds for Unequal Error Protection Codes*, under supervision of *Frank Vallentin*.
2015–2017	**Mathematics BSc**, *University of Cologne*, *cum laude* Thesis: *The Banach-Tarski Paradox*, under supervision of *Alexander Lytchak*.

Warandelaan 2, office K420 – 5037AB Tilburg, the Netherlands
✉ *d.brosch@tilburguniversity.edu* • *danielbrosch.com*

2012–2015 **Project**, *Schülerinnen und Schüler an der Universität*, University of Cologne
Project that allowed me to visit university early in parallel to high school.

2008–2015 **Abitur**, *Otto-Hahn-Gymnasium*, Monheim am Rhein
Abitur in Mathematics, Physics, Latin, Philosophy

Papers

Accepted

2021 **Jordan symmetry reduction for conic optimization over the doubly nonnegative cone: theory and software**, *Optimization Methods and Software*, joint work with *Etienne de Klerk*, `https://doi.org/10.1080/10556788.2021.2022146`
We extend the Jordan Reduction method to the doubly nonnegative cone, and describe a Julia software package implementing it.

2021 **Optimizing hypergraph-based polynomials modeling job-occupancy in queueing with redundancy scheduling**, *SIAM Journal on Optimization*, joint work with *Monique Laurent* and *Andries Steenkamp*, `https://doi.org/10.1137/20M1369592`
We show that a family of highly symmetric polynomials is convex, thus (partially) solving a problem coming from queueing with redundancy scheduling. To do this, we exploit the symmetries of the Hessians of the polynomials algebraically.

2020 **Minimum energy configurations on a toric lattice as a quadratic assignment problem**, *Discrete Optimization*, joint work with *Etienne de Klerk*, `https://doi.org/10.1016/j.disopt.2020.100612`
We bound the potential energy of charged particles on an infinite, periodic grid from below, using semidefinite programming and symmetry reduction based on the Jordan Reduction method.

Preprints

2022 **New lower bounds on crossing numbers of $K_{m,n}$ from permutation modules and semidefinite programming**, joint work with *Sven Polak*, `https://arxiv.org/abs/2206.02755`
We symmetry reduce SDP-based bounds for the crossing number of complete bipartite graphs, and improve bounds both in the finite case and in the limit. We also introduce a new, slightly weaker, but computationally more efficient bound for the crossing number of $K_{m,n}$, allowing us to compute bounds for bigger parameters m and n.

Work in progress

2020– **More efficient and flexible Flag-SOS hierarchies**
We exploit the symmetries of the SOS and moment hierarchies fully for the class of S_n-invariant polynomials over the k-subset-hybercube. This leads to computationally more efficient hierarchies equivalent to Razborov's Flag-SOS hierarchies, and extents their use case to finite and degenerate problems.

Software

2021 **SDPSymmetryReduction.jl**
Julia package for automatic symmetry reduction of SDPs using the Jordan Reduction method. Available at `https://github.com/DanielBrosch/SDPSymmetryReduction.jl`

Work in Progress

2021– **FlagSOS.jl**
Extendable Julia package for solving fully symmetry-reduced Flag-SOS problems for a variety of combinatorial objects.

Talks

July 26, 2022 **ICCOPT**, Betlehem, PA, USA
Moebius-Transformation Based Symmetry Reduction for Optimization in Binary Variables.

April 12, 2022 **Workshop on Conic Linear Optimization for Computer-Assisted Proofs**, Oberwolfach
The Symmetries of Flag-Algebras.

April 1, 2022 **Discrete Math Seminar**, University of Massachusetts Amherst
Symmetry reduced Flag-hierarchies.

March 23, 2022 **Polynomial optimization reading group**, CWI, Amsterdam
Symmetry reduced Flag-hierarchies.

August 20, 2021 **SIAM AG21**
More efficient and flexible Flag-Algebras coming from polynomial optimization.

July 20–23, 2021 **SIAM OP21**
More efficient and flexible Flag-Algebras coming from polynomial optimization.

February 2021 **Virtual OR seminar**, Tilburg University
More efficient and flexible Flag-Algebras.

January 2021 **Oberseminar *Reelle Geometrie und Algebra***, Uni Konstanz
More efficient and flexible Flag-Algebras.

January 2021 **Shared seminar Cologne Oberseminar/CWI reading group**
More efficient and flexible Flag-Algebras.

February 26, 2020 and March 4, 2020 — **Polynomial optimization reading group**, CWI, Amsterdam
A two-part introduction to symmetry reduction for SDPs

August 7, 2019 — **ICCOPT**, Berlin
Minimum energy configurations on a toric lattice as a quadratic assignment problem.

Conferences/Workshops/Summer Schools/Courses

June 7–9, 2022 — **Nordic Combinatorial Conference (NORCOM)**, Tromsø

April 10–15, 2022 — **Workshop on Conic Linear Optimization for Computer-Assisted Proofs**, Oberwolfach

June 21–29, 2021 — **MINOA Doctoral School 2021**, Online

April 16, 2021 — **General Julia training (POEMA)**, Online

March 4–5, 2021 — **Second MINOA ESR days**, Online

March 1–3, 2021 — **Annual MINOA Conference 2021**, Online

January–March 2021 — **POEMA 3rd Workshop**, Online

December 1, 2020 — **Complementary Skills Session on intellectual property rights**, Online

November 23–24, 2020 — **First MINOA ESR days**, Online

October–December 2020 — **POEMA 2nd Workshop**, Online

May 27–September 16, 2020 — **POEMA Online Learning Weeks**, Online

January 6–10, 2020 — **2nd MINOA conference**, Aussois, France

January 6–10, 2020 — **24th Workshop on Combinatorial Optimization**, Aussois, France

September 9–November 11, 2019 — **Interior Point Methods**, *LNMB PhD Course*, Etienne de Klerk, Utrecht, the Netherlands

August 5–8, 2019 — **6th International Conference on Continuous Optimization (ICCOPT)**, Berlin, Germany

June 24–28, 2019 — **1st MINOA PhD school**, *Mixed-Integer Nonlinear Optimization meets Data Science* , Ischia, Italy

January 14–16, 2019 — **1st MINOA conference**, Aussois, France

January 14–16, 2019 — **23rd Workshop on Combinatorial Optimization**, Aussois, France

January 7–11, 2019 — **44th conference on the mathematics of operations research**, Lunteren, the Netherlands

November 19–February 18, 2019 — **Networks and Semidefinite Programming**, *LNMB PhD Course*, Monique Laurent, Utrecht, the Netherlands

2019–Present **CWI reading group on polynomial optimization**, *hosted by* Monique Laurent, Sven Polak, CWI, Amsterdam

2020–Present **Oberseminar**, *hosted by* Frank Vallentin, Cologne

Teaching

Summer semester 2022 **Linear Algebra for Data Science**, Tutorials

Winter semester 2021-2022 **Linear Optimization**, Tutorials and computer labs

Last updated on September 19, 2022.