

STEFFEN BORGWARDT

Curriculum Vitae

Campus Address

Associate Professor
University of Colorado Denver
Department of Mathematical and Statistical Sciences
Denver, CO, 80204, USA
steffen.borgwardt@ucdenver.edu

EDUCATION

Habilitation, May 2015, 'Data Analysis through Polyhedral Theory',
Technische Universität München

Dr. rer. nat. in Mathematics, Dec. 2010, 'A Combinatorial Optimization Approach to Constrained Clustering', advisor: P. Grötzmann, Technische Universität München, summa cum laude

Diploma (M.Sc.) in Computer Science and **Diploma (M.Sc.) in Mathematics**, Mar. 2007,
Technische Universität München

PROFESSIONAL EXPERIENCE

Associate Professor, 9/19-current, and **Director of Graduate Programs**, 7/20-6/23, University of Colorado Denver, Department of Mathematical and Statistical Sciences

Assistant Professor, 9/16-8/19, University of Colorado Denver, Department of Mathematical and Statistical Sciences

Privatdozent, 9/15-8/16, Technische Universität München, Department of Mathematics

Visiting Assistant Professor, 9/14-8/15, University of California Davis, Department of Mathematics

Acting Associate Professor, 9/13-4/14, Technische Universität Braunschweig, Department of Mathematics

Head of Research and Development Project 'ArborChange', 4/12-8/13, Project of the Bavarian State Ministry for Nutrition, Agriculture and Forests

Postdoctoral Research Associate, 1/11-3/12 and 5/14-8/14, Technische Universität München, Department of Mathematics

JOURNAL PUBLICATIONS

S. Borgwardt, F. Happach, S. Zirkelbach (2023) An Algorithm for the Separation-Preserving Transition of Clusterings. **INFORMS Journal on Optimization** 5:1, pp. 1-26

S. Borgwardt, C. Viss (2022) A Polyhedral Model for Enumeration and Optimization over the Set of Circuits. **Discrete Applied Mathematics** 308, pp. 68-83 (university-wide best dissertation award for co-author)

- S. Borgwardt, C. Viss (2022) Circuit Walks in Integral Polyhedra. **Discrete Optimization** 44(1):100566
- S. Borgwardt (2022) An LP-based, Strongly Polynomial 2-Approximation Algorithm for Sparse Wasserstein Barycenters. **Operational Research** 22, p.1511-1551
- S. Borgwardt, S. Patterson (2022) A Column Generation Approach to the Discrete Barycenter Problem. **Discrete Optimization** 43:100674
- S. Borgwardt, C. Viss (2021) Constructing Clustering Transformations. **SIAM Journal on Discrete Mathematics** 35:1, pp. 152-178
- S. Borgwardt, C. Brand, A. Feldmann, M. Koutecky (2021) A Note on the Approximability of Deepest-Descent Circuit Steps. **Operations Research Letters** 49:1, pp. 310-315
- S. Borgwardt, S. Patterson (2021) On the Computational Complexity of Finding a Sparse Wasserstein Barycenter. **Journal of Combinatorial Optimization** 41:3, pp. 736-761
- S. Borgwardt, C. Viss (2020) An implementation of steepest-descent augmentation for linear programs. **Operations Research Letters** 48:3, pp. 323-328
- S. Borgwardt, S. Patterson (2020) Improved Linear Programs for Discrete Barycenters. **INFORMS Journal on Optimization** 2:1, pp. 14-33
- S. Borgwardt, F. Happach (2019) Good Clusterings Have Large Volume. **Operations Research** 67:1, pp. 215-231 (INFORMS student paper award for co-author)
- S. Borgwardt, R. Frongillo (2019) Power Diagram Detection with Applications to Information Elicitation. **Optimization Theory and Applications** 181:1, pp. 184-196
- S. Borgwardt, T. Stephen, and T. Yusun (2018) On the Circuit Diameter Conjecture. **Discrete & Computational Geometry** 60:3, pp. 558-587
- S. Borgwardt, J. De Loera, E. Finhold, and J. Miller (2018) The Hierarchy of Circuit Diameters and Transportation Polytopes. **Discrete Applied Mathematics** 240, pp. 8-24
- S. Borgwardt, J. De Loera, and E. Finhold (2018) The Diameters of Network Flow Polytopes satisfy the Hirsch Conjecture. **Mathematical Programming** 171:1-2, pp. 283-309
- S. Borgwardt, A. Brieden, and P. Gritzmann (2017) An LP-based k-means algorithm for balancing weighted point sets. **European Journal of Operational Research** 263, pp. 349-355
- E. Anderes, S. Borgwardt, and J. Miller (2016) Discrete Wasserstein Barycenters: Optimal Transport for Discrete Data. **Mathematical Methods of Operations Research** 84:2, pp. 389-409
- S. Borgwardt, S. Onn (2016) Efficient solutions for weight-balanced partitioning problems. **Discrete Optimization** 21:C, pp. 71-84
- S. Borgwardt, E. Finhold, and R. Hemmecke (2016) Quadratic diameter bounds for dual network flow polyhedra. **Mathematical Programming** 159:1, pp. 237-251

S. Borgwardt, J. De Loera, E. Finhold (2016) Edges vs Circuits: a Hierarchy of Diameters in Polyhedra. **Advances in Geometry** 16:4, pp. 511-530

S. Borgwardt, A. Brieden, and P. Gritzmann (2015) Geometrisches Clustering: Mathematik für die Flurverbesserung (Geometric clustering: Mathematics for land improvement). **Mitteilungen der DMV** 23/2015, pp. 82-90

S. Borgwardt (2015) On Soft Power Diagrams. **Mathematical Modelling and Algorithms in Operations Research** 14:2, pp. 173-196

S. Borgwardt, E. Finhold, and R. Hemmecke (2015) On the circuit diameter of dual transportation polyhedra. **SIAM Journal on Discrete Mathematics** 29:1, pp. 113-121

S. Borgwardt, S. Schaffner, M. Suda (2014) Geometrische Kennzahlen für die forstfachliche Bewertung der Zersplitterung von Privatwaldarealen (Geometric measures for the assessment of fragmentation of private forest areas). **Forstarchiv** 06/14, pp. 188-196

S. Borgwardt, A. Brieden, and P. Gritzmann (2014) Geometric clustering for the consolidation of farmland and woodland. **Mathematical Intelligencer** 36:2, pp. 37-44 (including front cover of journal)

S. Borgwardt, F. Schmiedl (2014) Threshold-based preprocessing for approximating the weighted dense k-subgraph problem. **European Journal of Operational Research** 234, pp. 631-640

S. Borgwardt (2013) On the Diameter of Partition Polytopes and Vertex-Disjoint Cycle Cover. **Mathematical Programming, Series A** 141:1, pp. 1-20

S. Borgwardt, A. Brieden, and P. Gritzmann (2011) Constrained Minimum-k-Star Clustering and its application to the consolidation of farmland. **Operational Research** 11:1, pp. 1-17

PREPRINT / IN REVIEW

S. Borgwardt, C. Buchanan, E. Culver, B. Frederickson, P. Rombach, Y. Yoo (2023) *Path Odd-Covers of Graphs*. available on arxiv:2306.06487

M.E. Eton, S. Borgwardt, D. Mays (2023) *Inverse Method to Determine the Hydraulic Conductivity Parameter from a Velocity Field using Graph Theory*. software available on HydroShare

A. Black, S. Borgwardt, M. Brugger (2023) *On the Circuit Diameter Conjecture for Counterexamples to the Hirsch Conjecture*. available on arxiv:2302.03977

S. Borgwardt, M. Brugger (2022) *Circuits in Extended Formulations*. available on arXiv:2208.05467

S. Borgwardt, S. Patterson (2022) *An Integer Program for Pricing Support Points of Exact Barycenters*. available on arXiv:2210.14135

S. Borgwardt, W. Grewe, J. Lee (2022) *On the Combinatorial Diameters of Parallel and Series Connections*. available on arXiv:2203.09587

OTHER PUBLICATIONS

A. Black, S. Borgwardt, and M. Brugger (2022) *Short Circuit Walks for Hirsch Counterexamples*. Technical Report available on arxiv:2302.03977v1

A. Malkis, S. Borgwardt (2019) *Binary Multithreaded Programs have Low Reachability-Complexity and Small Diameters*. Technical report

S. Borgwardt (2018) *Strongly Polynomial 2-Approximations for Discrete Wasserstein Barycenters*. Technical Report available on arxiv: 1704.05491v3

A. Malkis, S. Borgwardt (2017) *Reachability in Binary Multithreaded Programs Is Polynomial*. **ICDCS 17**, doi: 10.1109/ICDCS.2017.290

S. Borgwardt, J. De Loera, and E. Finhold (2016) *The Diameters of Transportation Polytopes satisfy the Hirsch Conjecture*. **2016 SIAM Workshop on Network Science**. Extended abstract. Full technical report available on arxiv: 1603.00325v1

S. Borgwardt (2015) *Data Analysis through Polyhedral Theory*, Habilitation thesis

S. Borgwardt, A. Malkis, and Y. Nagashima (2014) *On the Diameter of Multithreaded Programs: The Basic Case*. Technical report

S. Borgwardt, A. Brieden, and P. Gritzmann (2013) *Mathematics in Agriculture and Forestry: Geometric Clustering for Land Consolidation*. **IFORS news**, Dec. 2013

S. Borgwardt (2013) *Das Programm ArborTec – ArborChange mit ArborEval und ArborOpt*. Public report for the software engineered in project ArborChange of the Bavarian State Ministry for Nutrition, Agriculture, and Forests.

K. Borgwardt, S. Borgwardt, A. Feragen, N. Shervashidze (2011) *Balanced kernel k-means for comparing large graphs with landmarks*. Technical report

S. Borgwardt (2010) *A Combinatorial Optimization Approach to Constrained Clustering*, Ph.D. thesis

PUBLICATIONS IN PREPARATION

S. Borgwardt, W. Grewe, S. Kafer, J. Lee, L. Sanita (2023) *On the Complexity of Sign-Compatible Walks*. In preparation, estimated 12/23

S. Borgwardt, and A. Morrison (2023) *On Combinatorial Algorithms and Circuit Augmentation for Pseudoflows*. In preparation, estimated 9/23 (MIP conference poster award for co-author)

S. Borgwardt, W. Grewe, J. Lee (2023) *On the Diameter of a 2-Sum of Polyhedra*. In preparation, estimated 9/23

GRANTS

CURRENT

DoD-AFOSR Regular Grant 2021-24, received 4/21, 'The Hirsch-Conjecture for Totally-Unimodular Polyhedra', awarded by AFOSR, Airforce Office of Scientific Research, volume \$374,716, PI with co-PI Dr. Jon Lee, University of Michigan

NSF Standard Grant 2020-24, received 6/20, 'AF: Circuit Walks in Optimization', awarded by the NSF Division of Computing and Communication Foundations, Algorithmic Foundations program, volume \$233,560

Graduate Research Workshops in Combinatorics 2020-23, co-PI, received 2/20, awarded by the NSF Division of Mathematical Sciences, Combinatorics program, series of research workshops

PREVIOUS

Simons Foundation Collaboration Grant for Mathematicians 2017-22, received 6/17, 'Polyhedral Theory in Data Analytics', awarded by the Simons Foundation, volume \$42,000

ORS Large Grant, received 1/17, 'Constructing the Difference of Clusterings', awarded by the Office of Research Services, University of Colorado Denver, volume \$11,200

Research and Development Project 'ArborChange', 4/12-8/13, Project of the Bavarian State Ministry for Nutrition, Agriculture and Forests, volume \$110,000 + indirect costs and primary costs of Bavarian state for one year

AWARDS/HONORS

TEACHING

CU Denver Award for Excellence in Teaching, received 11/21, campus-wide, highest teaching award of the University of Colorado Denver, given annually to one faculty member

CLAS Award for Excellence in Teaching, received 3/21, College of Liberal Arts and Sciences, University of Colorado Denver

'TeachInf' Best Teaching Award, received 7/16, best undergraduate lecture 'Linear Algebra for Computer Science', Department of Computer Science, TU Munich

Two Outstanding Teaching Awards, received 3/13 and 7/14, Department of Mathematics, TU Munich

RESEARCH

Feodor Lynen Research Scholarship and lifetime **Humboldt Fellowship**, received 2/14, awarded by the Alexander-von-Humboldt Foundation, 'Data Analysis through the Geometry of Transportation Polytopes', volume ca. \$50,000

European Excellence in Practice Award 2013, received 7/13, 'Geometric clustering for the consolidation of farm- and woodland', joint with A. Brieden and P. Gritzmann, awarded by EURO, the Association of the European Operational Research Societies within IFORS

STUDENT RESEARCH AWARDS

Graduate School Best Dissertation Award, *Circuits in Optimization*, University of Colorado Denver, received 4/20. Charles Viss (phd student)

Fulbright Scholarship, US Department of State, started 2/20. Christina Ebben (master's student). First mathematics Fulbright to Brazil. Visit cut short due to covid. Reapplied and received a second time 1/21.

Second place award, 2018 Student Paper Prize Competition, INFORMS Optimization Society, for joint paper *Good Clusterings Have Large Volume*, received 11/18. Felix Happach (phd student)

GOR-Award 2017, for best master's thesis, national award of German Society of Operations Research (GOR), received 9/17. Felix Happach (master's student)

CONFERENCE AND SPECIAL SESSION ORGANIZATION

Conference Organization

Organizing Committee, co-PI
Graduate Research Workshop in Combinatorics, July 2023
University of Wyoming

Conference Organization

Workshop on Circuit Diameters and Augmentation, May 2023
Organized as PI for NSF grant
hosted at the University of Colorado Denver

Conference Organization

Organizing Committee, co-PI
Graduate Research Workshop in Combinatorics, August 2022
hosted at the University of Colorado Denver

AMS Special Session Organization

Joint Mathematics Meeting, January 2020
Colorado Convention Center, Denver

Conference Organization

Organizing Committee
INFORMS Optimization Society Meeting, March 2018
hosted at the University of Colorado Denver

Conference Organization

Organizing Committee
Colloquium in Honor of the 60th Birthday of Peter Gritzmann, Dec. 2014
hosted at the Technische Universität München

Conference Organization

Organizing Committee
ECCO-CO 2014 – European Chapter on Combinatorial Optimization, May 2014
hosted at the Technische Universität München

INVITED COLLOQUIUM/SEMINAR TALKS, RESEARCH VISITS

2022

University of Colorado Boulder
Technische Universität München

2021

University of Passau

2019

Ulm University
Technische Universität München
University of Colorado Denver, College of Engineering, Design and Computing

2018

Colorado State University

2017

Technische Universität München
University of Wyoming
INFORMS Rocky Mountain Chapter Meeting
University of Colorado Boulder (twice)

2016

Simon Fraser University Surrey
Simon Fraser University Burnaby
University of Colorado Denver
Georgia Southern University
Northern Illinois University
Technische Universität Chemnitz

2015

Maastricht University
Cardiff University
University of Edinburgh
University of California Los Angeles
University of North Carolina Chapel Hill

2014

Technion – Israel Institute of Technology, Haifa

2013

University of California Davis
Technische Universität Dortmund
Universität Hamburg
Technische Universität Hamburg-Harburg

2012

Goethe-Universität Frankfurt
Max-Planck Institute Tübingen

CONFERENCE AND WORKSHOP PRESENTATIONS, SESSION CHAIR

2023

'Combinatorics and Optimization', ICERM, Providence

2022

CAIMS Annual Meeting 2022, Kelowna

2021

Hausdorff Institute, Bonn

2020

Joint Mathematics Meetings 2020, Denver

2019

Joint Mathematics Meetings 2019, Baltimore

2018

ORS Immigration Research Meeting, Denver

'Optimization and Discrete Geometry: Theory and Practice', Tel Aviv

INFORMS Optimization Society Meeting 2018, Denver

2017

SIAM Optimization 2017, Vancouver

2015

DMV-Jahrestagung 2015, Hamburg

ISMP 2015, Pittsburgh

'Paths, Pivots, and Practice: The Power of Optimization', Montreal

2014

IFORS 2014, Barcelona

ECCO-CO 2014, Munich

2013

EURO 2013, Rome

2012

ISMP 2012, Berlin

EURO 2012, Vilnius

ECCO 2012, Antalya

2010-2020, 2022-23

Participation in 17 interdisciplinary workshops and 8 conferences (without presentations)

PROFESSIONAL ORGANIZATIONS (MEMBERSHIP)

AMS – American Mathematical Society

SIAM – Society of Industrial and Applied Mathematics

INFORMS – The Institute for Operations Research and the Management Sciences

DHV – Deutscher Hochschulverband

COURSES TAUGHT

CU DENVER (College and campus-level awards 2021 for Excellence in Teaching)

Applied Linear Algebra (5 times)
Independent Study (3 times)
Integer Programming (4 times)
Introduction to Operations Research
Linear Programming (4 times)
Network Flows (3 times)
Readings: Optimization (13 times)
Topics in Optimization

TU MUNICH, UC DAVIS, TU BRAUNSCHWEIG, ISM MUNICH

Algebraic and Geometric Techniques for Optimization (problem session) (teaching award)
Applied Discrete Mathematics (problem session)
Combinatorial Optimization (problem session)
Computational Complexity in Optimization (problem session) (teaching award)
Discrete Mathematics in Data Analytics (seminar)
Discrete Optimization
Game Theory 1 (seminar)
Game Theory 2 (seminar)
Introduction to Discrete Mathematics
Linear Algebra
Linear Algebra for Computer Science (best teaching award *TeachInf*, 2016)
Linear Optimization
Mathematics 1
Mathematics 1 for Electrical Engineering (problem session)
Mathematics 2 for Electrical Engineering (problem session)
Mathematics and Computers
Mathematical Methods for the Business Sciences 2 (problem session)
Optimization 1 (problem session)
Optimization 2 (problem session)
Optimization 3 (problem session)
Programming Course: Optimization 1
Programming Course: Optimization 2
Selected Topics from Combinatorial Optimization (seminar)

MENTORING

PHD

Nick Crawford, CU Denver, comprehensive exam 9/23
Angela Morrison, CU Denver, PhD candidate, thesis proposal 4/23
Weston Grewe, CU Denver, PhD candidate, expected graduation AY 23-24
Zachary Sorenson, CU Denver, PhD candidate, expected graduation AY 24-25
Matthias Brugger, TU Munich, PhD candidate, co-mentor, two joint papers (without primary advisor), expected graduation AY 23-24
Felix Happach, TU Munich, co-mentor, PhD completed 10/20, two joint papers (without primary advisor), INFORMS Student Paper Prize 2018 (see awards)
Charles Viss, CU Denver, 'Circuits in Optimization', PhD completed 4/20, Best Dissertation Award (see awards)
Stephan Patterson, CU Denver, 'Algorithms for Discrete Barycenters', PhD completed 3/20

MASTER, BACHELOR, HONORS, READINGS

12 completed master's projects, a student received best master's thesis award from GOR - Gesellschaft für Operations Research (see awards)
10 completed bachelor's and honors projects
16 directed research, independent study, and readings classes since 2016

LEADERSHIP AND SERVICE

AY 2022-23

Graduate Program Director

Degree program reviews, 7-year reviews for Higher Learning Commission, PhD and MS in Applied Mathematics

Conference organization: Workshop on Circuit Diameters and Augmentation, PI and host

CLAS Dean's Advisory Committee for IRCF Personnel Decisions

Executive Committee

Merit Committee, Chair

Excellence in Teaching Award, Faculty Mentoring Award Selection Committees
NSF Panel

Search Committee for Director of Graduate Recruitment

Conference organizing committee, GRWC 2023, preparation & mentoring

Conference organizing committee, GRWC 2022, local host

Co-Organization of Operations Research Seminar

Doctoral committee for ten students (two external), and honor's committee for external student
Catalog editor for department

AY 2021-22

Graduate Program Director

Graduate Admissions Committee

Executive Committee

Initial Appointment Committee

Excellence in Teaching Award, Faculty Mentoring Award Selection Committees

Conference organizing committee, GRWC 2022, preparation & mentoring

Co-Organization of Operations Research Seminar

Faculty Advisor of the CU Denver Machine Learning Club

Doctoral committee for nine students (two external), master's committee for two students

Catalog editor for department

AY 2020-21

Graduate Program Director

Graduate Admissions Committee

Executive Committee

RTP Committee

Merit Committee

Co-Organization of Operations Research Seminar

Faculty Advisor of the CU Denver Machine Learning Club

Doctoral committee for three students, master's committee for two students

Graduate School Fair, Joint Mathematics Meetings 2021, department booth

AY 2019-20

Graduate Admissions Director

Executive Committee

Faculty Assembly

RTP and PTR Committees

Co-Organization of Operations Research Seminar

Faculty Advisor of the CU Denver Machine Learning Club

Doctoral committee for four students (one thesis subm.), master's committee for three students

Data to Policy Symposium, judge (fall 2019), participation with classes and machine learning club

Graduate School Fair, Joint Mathematics Meetings 2020, department booth

AMS Special Session organization, Joint Mathematics Meetings 2020

AY 2018-19

Search Committee, co-chair, Assistant Professorship in Optimization (chair after Dec. 15)

Executive Committee

Undergraduate Committee

Preliminary Committee, chair, Linear Algebra (summer 2019)

Faculty Assembly

Co-Organization of Operations Research Seminar

Faculty Advisor of the CU Denver Machine Learning Club

STEAMposium, outreach to K-12 and STEM students, department booth

Doctoral committee for four students (incl. thesis proposal for own student), master's committee for two students

Data to Policy Symposium, participation with two classes

Session organization, Joint Mathematics Meetings 2019

AY 2017-18

Conference organizing committee, Informs Optimization Society Meeting 2018

Search Committee, Assistant Professorship in Optimization

Co-Organization of Operations Research Seminar

Faculty Advisor of the CU Denver Machine Learning Club

Doctoral committee for four students (incl. thesis proposal and comprehensive exam for own student), master's committee for two students

CU Denver Sustainability Day, two talks *Mathematics and Sustainable Agriculture* for K-12 students

Session organization, Informs Optimization Society Meeting 2018

AY 2016-17 AND EARLIER

Minisymposium Organization, SIAM Conference on Optimization 2017

Preliminary Committee Linear Algebra

Co-Organization of Operations Research Seminar

Doctoral committee for two students, honor's committee for two students

Foundations of Mathematics exams, TU Munich, 2016

Moderator for the 26th undergraduate student conference, UC Davis, 2015

Conference organizing committee, Colloquium in Honor of the 60th Birthday of Peter Gritzmann

Conference organizing committee, ECCO-CO 2014 – Euro Chap. on Combinatorial Optimization

IFORS 2014, Barcelona, organizer of stream 'Geometric Clustering'

EURO 2013, Rome, organizer of stream 'Geometric Clustering'

GENERAL

Reviewer of more than 50 articles and 20 grant proposals for about 25 journals and organizations 2013-2023