LUKAS NABERGALL

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Education

Ph.D. in Combinatorics and Optimization September 2017 — December 2022
University of Waterloo, Waterloo, Ontario
Advisor: Karen Yeats
Thesis: *Enumerative perspectives on chord diagrams*
Relevant Coursework: Deep Learning in Computational Discrete Optimization, Combinatorial Optimization, Graph Theory

B.A./M.A. in Mathematics August 2013 — August 2017
University of South Florida, Tampa, Florida
Advisors: Nataša Jonoska and Masahico Saito
Thesis: *Patterns in Words Related to DNA Rearrangements*
Relevant Coursework: Machine Learning, Statistics, Materials Physics, Algebraic Automata Theory, Advanced Linear Algebra, Symbolic Computations, Partial Differential Equations

Experience

Graduate Research Assistant September 2017 — August 2022
University of Waterloo

- Studied the exact enumeration of restricted hereditary classes of chord diagrams, determining the counting sequences of numerous such classes.
- Constructed structural decompositions for chord diagrams to solve certain Dyson-Schwinger equations from quantum field theory.

Teaching Assistant September 2017 — August 2022
University of Waterloo

- Conducted tutorials, graded assignments, and proctored exams for e.g. Algebraic Enumeration, Deterministic Operations Research Models, and Linear Algebra.

Graduate Research Assistant August 2016 — August 2017
University of South Florida, Math/Bio Lab

- Using topological and graph-theoretic methods, investigated the connectivity of words under certain string operations.

Graduate Instructional Assistant August 2016 — May 2017
University of South Florida

- Graded assignments and proctored tests for Engineering Calculus I and Linear Algebra.

Undergraduate Research Assistant May 2015 — August 2016
University of South Florida, Math/Bio Lab

- Investigated generalized patterns in words and explored the properties of indices and distances on words defined via pattern removal operations.
- Applied these patterns, indices, and distances to the study of highly complex genome rearrangements in the ciliate *Oxytricha trifallax*.

Undergraduate Researcher October 2013 — January 2015
University of South Florida

- Produced some weak improvements to the best known inequalities approaching Vizing's conjecture on the domination number of the Cartesian product of graphs.

- Examined the domination number of the Cartesian product of Erdős-Rényi random graphs.

Student Researcher June 2012 — August 2012
Camp Euclid
Advisor: Dr. David Gay

- Investigated Goldbach's conjecture, Pascal's triangle, and a polygon unfolding problem.
- Collaborated with other students from around the world.

Publications

A. A. Mahmoud, L. Nabergall, *Pattern avoidance and connectivity in chord diagrams*, in submission.

P.-H. Balduf, A. Cantwell, K. Ebrahimi-Fard, L. Nabergall, N. Olson-Harris, K. Yeats, *Tubings, chord diagrams, and Dyson-Schwinger equations*, accepted into J. London Math. Soc.

L. Nabergall, *The combinatorics of a tree-like functional equation for connected chord diagrams*, Combinatorial Theory, **3**:3 (2023), doi:10.5070/C63362791.

D. A. Cruz, M. M. Ferrari, N. Jonoska, L. Nabergall, M. Saito, *Insertions Yielding Equivalent Double Occurrence Words*, Fundamenta Informaticae, **171**:1–4 (2020) 113–132, doi:10.3233/FI-2020-1875.

L. Nabergall, J. Toth, L. Cousins, *Training Hard-Threshold Networks with Combinatorial Search in a Discrete Target Propagation Setting*, previously submitted to ICLR.
openreview.net/pdf?id=rkeX-3Rqtm.

L. Nabergall, A. Navas, E. Winsberg, *An antidote for hawkmoths: On the prevalence of structural chaos in non-linear modeling*, European Journal for Philosophy of Science, **9**:21 (2019), arXiv:1706.07528.

J. Braun, L. Nabergall, R. Neme, L. Landweber, M. Saito, N. Jonoska, *Russian Doll Genes and Complex Chromosome Rearrangements in Oxytricha trifallax*, G3: Genes, Genomes, Genetics, **8**:5 (2018) 1669–1674, doi:10.1534/g3.118.200176.

N. Jonoska, L. Nabergall, M. Saito, *Patterns and Distances in Words Related to DNA Rearrangement*, Fundamenta Informaticae, **154** (2017) 225–238, doi:10.3233/FI-2017-1563.

Projects

8-bit Breadboard Computer

- ∼500 Hz, 16 byte RAM; modified version of Ben Eater's design.
- Constructed to gain further familiarity with electronics and computer hardware design.

CollaboRatings - CDP Climate Hackathon 2020 Winner

- Constructed and visualized a KPI model for cross-sector collaboration on climate mitigation strategies between US cities and corporations.
- Analyzed free-form responses in CDP surveys using spaCy text embeddings to automatically identify potential agreement on climate issues.
- Competed as Team Rocket with Savannah Wu, Alejandro Navas, and Cynthia Wang.

Terrace: PyTorch Utilities Library
github.com/lnabergall/terrace

- A framework built on top of PyTorch that adds customizable data input and processing pipelines, training, evaluation, and monitoring tools, and a variety of standard machine learning components, including evaluation metrics, hyperparameter containers, regularizers, and more.
- Supports supervised, unsupervised, and reinforcement learning, among other paradigms.

MultiLM
github.com/lnabergall/multi-lm

- Trained and evaluated multilingual and, eventually, multi-domain language models using a simple modification to standard neural language models.
- Observed significant transfer learning and a small increase in perplexity as the number of languages increases.

Li-Fi Transmitter and Receiver

- Designed and constructed a prototype Li-Fi transmitter and receiver capable of communicating high-bandwidth audio over a significant distance.
- See this YouTube video for a demonstration of the system, completed collaboratively with Mark Steele, Nathan Hayford, Carlton Drew, Nikki Hudson, and Zhimin Shi at USF.

WordExplorer
github.com/lnabergall/word-explorer

- A library that implements a variety of tools for working with words, patterns, pattern indices, and pattern-based word distances.
- Based on a series of papers co-authored with Nataša Jonoska, Masahico Saito, Jasper Braun, and others.

Knowledge Database
github.com/lnabergall/knowledge-database

- The backend for an open, editable, structured knowledge store (i.e. a wiki variant).
- Includes a robust voting system for managing edits, mechanisms to boost transparency, and shorter, more structured articles (or content pieces) than Wikipedia, making it better suited for the accumulation and distribution of research-oriented subject knowledge.

Invited Talks

Finding structure in chord diagrams November 24, 2022
ICE-TCS Research Seminar, Reykjavik University, Iceland

The enumerative universe of chord diagrams May 13, 2022
Ontario Combinatorics Workshop, University of Waterloo, Ontario

Enumerating hereditary classes of chord diagrams June 10, 2021
Algebraic Combinatorics Seminar, University of Waterloo, Ontario

Weighted generating functions for weighted chord diagrams June 4, 2020
Algebraic Combinatorics Seminar, University of Waterloo, Ontario

Connectivity and terminal chords in chord diagrams December 9, 2019
CMS Winter Meeting, Toronto, Ontario

Complex Rearrangements in the Highly Scrambled Genome of O. trifallax June 15, 2016
The Allied Genetics Conference, Orlando, Florida

Recurring Patterns in a Highly Scrambled Ciliate Genome April 6, 2016
USF Research and Arts Colloquium, Tampa, Florida

Patterns and Distances for Double Occurrence Words February 27, 2016
MAA-FTYCMA Joint Conferences
Saint Leo University, Saint Leo, Florida

Skills

Programming/Scripting: Python, C, PyTorch, HTML, CSS, LaTeX
Languages: English, Danish