LUKAS NABERGALL

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Education

Ph.D. in Combinatorics and Optimization September 2017 — December 2022
University of Waterloo, Waterloo, ON
Advisor: Dr. Karen Yeats
Thesis: *Enumerative perspectives on chord diagrams*
Relevant Coursework: Deep Learning in Computational Discrete Optimization, Combinatorial Optimization, Graph Theory, Analytic Number Theory, Algebraic Enumeration, Feynman Diagrams, Public-Key Cryptography, Matroid Theory, Combinatorial Hopf Algebras

B.A./M.A. in Mathematics August 2013 — August 2017
University of South Florida, Tampa, FL
Advisors: Dr. Nataša Jonoska and Dr. Masahico Saito
Thesis: *Patterns in Words Related to DNA Rearrangements*
Relevant Coursework: Independent Study in Machine Learning, Materials Physics, Algebraic Automata Theory, Advanced Linear Algebra, Symbolic Computations, Statistics, Partial Differential Equations, Differential Geometry, Topology, Independent Study in General Relativity, Graph Theory, Abstract Integration, Applied Complex Analysis, Real Analysis

Experience

Graduate Research Assistant September 2017 — August 2022
University of Waterloo
Advisor: Dr. Karen Yeats

- Studied the exact enumeration of restricted hereditary classes of chord diagrams.
- 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
Department of Combinatorics and Optimization

- Conducted tutorials, graded assignments, and proctored exams for MATH 115 Linear Algebra, MATH 239 Introduction to Combinatorics, CO 630 Algebraic Enumeration, and CO 370 Deterministic Operations Research Models.

Graduate Research Assistant August 2016 — August 2017
University of South Florida, USF Math/Bio Lab
PI: Dr. Nataša Jonoska and Dr. Masahico Saito

- 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
Department of Mathematics and Statistics

- Graded assignments and proctored tests for MAC 2281 Engineering Calculus I and MAS 3105 Linear Algebra.

Undergraduate Research Assistant May 2015 — August 2016
University of South Florida, USF Math/Bio Lab
PI: Dr. Nataša Jonoska and Dr. Masahico Saito

- 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
Advisor: Dr. Stephen Suen

- 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 International Conference on Learning Representations.

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 a variety of machine learning paradigms, including supervised, unsupervised, and reinforcement learning.
- Open-sourced.

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, students and professors at the University of South Florida.

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 encourage user transparency, and shorter, more structured articles (or content pieces) than Wikipedia, making it better suited for the accumulation and distribution of advanced 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 and Enumerative Combinatorics Seminar
University of Waterloo, Ontario

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

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

Patterns in Words Related to DNA Rearrangements March 10, 2017
Master's Thesis Defense
University of South Florida, Tampa, Florida

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
University of South Florida, Tampa, Florida

Patterns and Distances for Double Occurrence Words — March 4, 2016
USF Math Club
University of South Florida, Tampa, Florida

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

Skills

Programming: Python, C++, Java, LaTeX, HTML, CSS

Languages: English, Danish