Nico Courts

Ph.D. Candidate
University of Washington Department of Mathematics
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EDUCATION

Ph.D., Mathematics — June 2022 (expected)
University of Washington, Seattle, WA

Master of Science, Mathematics — March 2020
University of Washington, Seattle, WA
Thesis Topic: Schur Duality and Strict Polynomial Functors (paper on github)

Bachelor of Science, Mathematics — May 2016
Magna Cum Laude, Phi Beta Kappa, Dean's List, Departmental Honors
University of Southern California, Los Angeles, CA

Budapest Semesters in Mathematics — Fall 2015
Algebraic Topology, Conjecture & Proof, Cryptography, Differential Geometry
Budapest, Hungary

Associate of Science, Mathematics — June 2013
Key of Knowledge, Dean's list, Honors Program
Citrus College, Glendora, CA

RESEARCH INTERESTS

Representation Theory
I am a student of Prof. Julia Pevtsova studying the representation theory of certain Hopf Algebras called bosonized quantum complete intersections. As their names suggest, they are close noncommutative relatives of complete intersection rings and have a similar flavor to their classical cousins. I am interested in particular in studying different notions of support for these algebras in the hopes of establishing an incarnation of the beloved tensor product property of support.

Machine Learning
I am also an intern with Pacific Northwest National Laboratory under the instruction of Dr. Henry Kvinge. I am particularly interested in using my familiarity with concepts from algebra, category theory, and geometry to enhance the current understanding of deep learning models with a focus towards providing more robust interpretability. Thus far my experience has included few-shot learning and generative models (specifically invertible NNs for normalizing flows), both of which have resulted in papers.

INTERNSHIPS

NSIP PhD Intern — June 2020 – Present
Pacific Northwest National Labs, Seattle, WA

A full-time summer internship spanning 2020 and 2021 including part-time work over the intervening school year. Our first 10 week project was focused on machine learning algorithms that could incorporate user input at inference time to hone results. Few-shot learning was the natural place to focus our energy and we developed and implemented *Fuzzy Simplicial Networks*, a metric-based model that we showed was able to make strong inferences on transfer tasks without fine-tuning by exploiting the geometry of feature space.

During the 2020/2021 year, some of my work on out-of-support detection for few-shot learning culminated in a paper along with my collaborators, although my contribution to this work was limited due to my scholarly responsibilities.

Finally, in summer 2021 we joined a team of data scientists who were interested in helping material scientists at the lab understand and refine their fabrication methods. Inspired by the idea of fiber bundles from topology, we developed a new generative architecture based on invertible neural nets like RNVP and GIN that used local trivializations to achieve superior density estimations than several GANs. In addition, our architecture was able to sample from the "fiber" over a point (all the points in input space that map to a particular point) much more effectively than simply conditioning on the output.

PREPRINTS

Bundle Networks: Fiber Bundles, Local Trivializations, and a Generative Approach to Exploring Many-to-one Maps
Nico Courts and Henry Kvinge
Submitted to ICLR 2022
Preprint available at https://arxiv.org/abs/2110.06983

One Representation to Rule Them All: Identifying Out-of-Support Examples in Few-shot Learning with Generic Representations
Henry Kvinge, Scott Howland, Nico Courts, Lauren A. Phillips, John Buckheit, Zachary New, Elliott Skomski, Jung H. Lee, Sandeep Tiwari, Jessica Hibler, Courtney D. Corley, Nathan O. Hodas
Preprint available at https://arxiv.org/abs/2106.01423

PUBLICATIONS

Fuzzy Simplicial Networks: A Topology-Inspired Model to Improve Task Generalization in Few-shot Learning
Henry Kvinge, Zachary New, Nico Courts, Jung H. Lee, Lauren A. Phillips, Courtney D. Corley, Aaron Tuor, Andrew Avila, Nathan O. Hodas
AAAI Workshop on Meta-Learning and MetaDL Challenge, PMLR 140:77-89, 2021.
Available at https://proceedings.mlr.press/v140/kvinge21a.html

TEACHING EXPERIENCE

Graduate Teaching Assistant Autumn 2016 – Present
University of Washington, Seattle, WA

- **As an instructor:**
  - Math 124 – Calculus I (Su 2018)
  - Math 208 – Matrix Algebra (Sp 2019)
- **As a teaching assistant:**
  - Math 120 – Precalculus (Au 2017)
  - Math 124 – Calculus I (Wi 2017, Wi 2019, Sp 2020)
  - Math 125 – Calculus II (Au 2016, Sp 2017, Wi 2021)
  - Math 126 – Calculus III (Su 2017, Wi 2018, Sp 2018, Au 2020)
  - Math 208 – Matrix Algebra (Au 2021)
  - Math 327 – Introductory Real Analysis (Su 2019)
  - Math 381 – Discrete Mathematical Modeling (Au 2018)
  - Math 403 – Group Theory (Wi 2020)

Lead Teaching Assistant and Instructor Summer 2016
SCS Noonan Scholars (previously South Central Scholars), Los Angeles, CA

- Independently developed and delivered approximately 50 hours of instruction and five exams to gifted university-bound students in calculus 2 and 3.
- Total of 100 contact hours, including daily supervised worksheet sessions.
- Took the initiative to deliver weekly lectures in higher mathematics (number theory, knot theory, differential equations, etc.) along with entry-level problems that allowed students to get a sense of the "flavor" of these fields.

Various Teaching and Mentorship Positions Spring 2012 – Summer 2013
Citrus College, Glendora, CA

- **PAGE Program Tutor** Assisted a licensed teacher in the education of a class of middle school children intended to reinforce the previous year's learning and to prevent "backsliding". Personally instructed a small group of students who were prepared to learn more advanced topics in intermediate algebra.
- **SIGMA Mentor** Took on a small group of students each semester utilizing a holistic approach to education – supplementing standard tutoring with more in-depth educational guidance and planning.
- **Math Tutor** Instructed students in the fast-paced Math Success Center where I provided homework help in all math classes through linear algebra and differential equations.

LEADERSHIP & SERVICE

Washington Directed Reading Program
Co-organizer
Autumn 2019 - Spring 2021

- Helped run the WDRP along with two other students. Each quarter we read applications, made acceptance and pairing decisions, held several events for enrichment and networking, and handled the administrivia required to keep projects running smoothly.

Mentor

- Introduced a student to group representation theory based on Artin's *Algebra* as well as Fulton & Harris' *Representation Theory* (Autumn 2021).
- Supervised an undergraduate student in a reading course based around Rebecca Weber's book *Computability Theory* (Autumn 2018).

Institute for the Quantitative Study of Inclusion, Diversity, and Equity (QSIDE) – Datathon4Good
Team Leader
October 2021

- Served alongside a faculty member to help guide a team of 13 students and faculty from across the country in applying data analysis and visualization tools in service of social justice.
- Brought in my experience in math, computer science, and data visualization to help guide the team in their analysis of two datasets related to incarceration and criminal justice.

LEADERSHIP & SERVICE (CONT.)

Graduate Student Representative
University of Washington, Seattle
Summer 2019 - Spring 2020

- Planned and organized a variety of events and lectures for the graduate students as well as the department at large.
- Served as an advocate for the graduate students in several capacities.
- Worked on promoting better communication between the students and faculty.
- Empowered students to make changes to the department while promoting respect for the wishes of the faculty and administration.

Departmental Union Steward
University of Washington, Seattle
Winter 2020 - Present

Math Hour Olympiad
Volunteer Judge
University of Washington, Seattle
Spring 2018

Math Day
Volunteer
University of Washington, Seattle
2017 and 2018

SEMINARS ORGANIZED

Pacific Northwest Seminar on Topology, Algebra, and Geometry in Data Science (TAG-DS)
Co-Organizer
Joint seminar between UW and PNNL platforming speakers who work at the intersection of pure math and data science.
Autumn 2021 – present

Departmental Current Topics Seminar
Organizer
Internal seminar for professors to talk about their research with the hopes of joining students with potential advisors.
Autumn 2019

TALKS GIVEN

Fuzzy Simplicial Networks: A Topology-Inspired Model to Improve Task Generalization in Few-shot Learning
5th Workshop on Geometry and Machine Learning
International Symposium on Computational Geometry (online)
June 8, 2021

Geometry of the Loss Landscape (presenter/discussion leader)
PNNL Math of Machine Learning Reading Group
Pacific Northwest National Laboratory (online)
March 24, 2021

Schur Algebras & Duality
Special Colloquium Series for Mathematical Sciences
Georgia Southern University (online)
November 20, 2020

EVENTS ATTENDED

International Conference on Machine Learning
Online
June 2021

International Conference on the Representation of Algebras
Online
November 2020

Conference on Lie and Jordan Algebras and their Representations
Sichuan University
Chengdu, Sichuan Province, P.R. China
January 2020

Triangulated Categories in Representation Theory and Geometry
University of Sydney
Sydney, NSW, Australia
June 2019

MSRI Summer School
The Mathematics of Machine Learning
University of Washington
Seattle, WA
July 29 - August 9, 2019

ABC Workshop
Geometric and Cohomological Methods in Algebra
University of Washington
Seattle, WA
November 11, 2018

Joint Mathematical Meetings
Seattle, WA
January 2016

SKILLS & HOBBIES

Languages:

- *English* – This is my native language.
- *German* – Ich kann ziemlich gut Deutsch sprechen, lesen, und verstehen! (proficient)
- *Russian* – Я немного понимаю по-русски. (beginner)
- *Programming* – **Go**, Haskell, Java, **Javascript, LaTeX**, PHP, **Python**.

Computer Skills: Web/application development, server administration, Sage, Windows, Linux, FreeBSD.

Life Skills: Critical thinking, abstract reasoning, communication, objectivity, empathy.

Hobbies: Hiking, jogging, rollerskating, and appreciating the wonders of the pacific northwest.