

jacobdenson

Mathematics Student

Research Interests

Harmonic Analysis,
Geometric Measure
Theory, Additive
Combinatorics.

Contact Information

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Stack Overflow:
[jacob-denson](#)
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<https://jdjake.github.io/>

Languages

English, Elementary
German, Very Rusty
Elementary Chinese,
Python, Perl, C++, C,
C#, Matlab, HTML,
Javascript, Latex
(This resume is proof!)

Education

2017-Present

Master's in
Mathematics
University of British
Columbia.

2013-2017

Bachelors in
Computing Science
University of Alberta.

Summary

I am a masters student at the University of British Columbia, applying my strong and diverse foundation in mathematical knowledge to do research in the harmonic analysis research group, studying continuous variants of discrete configuration avoidance problems emerging from additive combinatorics. My previous work in theoretical computing science has given me a strong knowledge of the algorithmic viewpoint of problems, which gives me a fresh perspective on classical ideas in the field. I am currently working on the problem of finding high dimensional fractals avoiding patterns.

Talks¹

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|------|---|--------------------------------|
| 2018 | CMS WINTER MEETING & MAAM 2018
Fractals Avoiding Fractal Sets
A twenty minute talk discussing my solution to a research problem constructing fractal sets of high Hausdorff dimension avoiding patterns. I emphasized the idea behind the switch from a continuous problem to a discrete scale argument, as well as discussing the strategy of the hypergraph avoidance method at the single scale. | CMS & University of Virginia |
| 2018 | DIFFERENTIAL TOPOLOGY CLASS
Hodge Theory: Harmonic Analysis in Topology
An hour talk discussing how the eigenfunctions of the Laplacian on a Riemannian manifold reflect the topology of the underlying manifold. I introduced the inner product of differential forms, the Hodge star, and the Laplace-Beltrami operator, and how these eigenfunctions can be used to give almost trivial proofs of major results about De Rham cohomology. | University of British Columbia |
| 2018 | MODULAR FORMS CLASS
Theta Functions
An hour long talk discussing how the theory of theta functions fits in with the general theory of modular forms once we introduce half weight forms and a modular symmetry with respect to a Dirichlet character. Using this theory, we prove Fermat's theorem on the sums of two squares, and Jacobi's theorem on the sums of four squares. | University of British Columbia |
| 2018 | TOPICS IN HARMONIC ANALYSIS CLASS
Radon Transform and Exceptional Projections
An hour talk connecting the Marstrand projection problem in geometric measure theory to harmonic analysis using the Radon transform. Bounding variants of the Radon transform gives results about the dimension of the set of projections where Marstrand's theorem fails. Based on Daniel M. Oberlin's paper "Restricted Radon Transforms and Projections of Planar Sets". | University of British Columbia |

¹ Notes for my talks can be found on my website: <https://jdjake.github.io/>

Awards 2018 NSERC CGSM UBC Science Graduate Award (2nd Time) 2017 UBC Science Graduate Award U of A Dean's Silver Medal in Science NSERC USRA (2nd and 3rd Time) 2016 Jason Lang Scholarship (3rd Time) 2015 Jason Lang Scholarship (2nd Time) 2014 NSERC USRA Jason Lang Scholarship 2013 U of A Academic Excellence Scholarship U of A Science Academic Excellence Scholarship Alexander Rutherford Achievement Scholarship	2017	GRADUATE SEMINAR Proofs in Three Bits or Less An hour talk introducing nonspecialists to the theory of probabilistically checkable proofs, and PCP theory. By changing the language by which we discuss the theory from accessing random bits from a string, to 'playing a game of 20 questions', I introduced a novel way to discuss the theory which avoids the technicalities of the field, making the talk accessible to students without any background in theoretical computing science. The ideas behind this talk were the basis for my published article in the 2018 edition of the Notes from the Margin expository journal.	University of British Columbia
	2016	NONCOMMUTATIVE HARMONIC ANALYSIS CLASS Canada Why Physicists Care About The Fourier-Stieltjes Transform A 20 minute talk emphasizing the naturality of the generalization of the Fourier transform to the Fourier-Stieltjes transform by proving the weak * density of $L^1(G)$ in $M(G)$, and discussing why this matters.	University of Alberta,
	2016	NONCOMMUTATIVE HARMONIC ANALYSIS CLASS Canada A Brief Respite In Abelian Analysis A 20 minute talk introducing the abstract Fourier transform on abelian locally compact groups, and discussing the generalization of the Poincare summation formula to this domain, which hints at the depth of Pontryagin duality.	University of Alberta,
	2016	CUMC CONFERENCE On Molecular Gases and the Natural Numbers A talk introducing Ergodic theory to undergraduate students, and emphasizing its relation to a variety of problems in mathematics, especially number theory.	University of Victoria, Vancouver Island
	2016	ALGEBRAIC TOPOLOGY GRADUATE CLASS Vector Fields, Hex, and Jordan Curves A 20 minute talk on the Brouwer fixed-point theorem, emphasizing the intuitive vector field interpretation of the theorem, and discussing how the fixed-point theorem relates to the combinatorial game of hex, reflecting the nice interweaving of discrete and point-set methods in algebraic topology.	University of Alberta, Canada
	2015	MICROSOFT INTERN TALKS Category Theory for Computer Programmers My original talk on category theory, shortened to a 20 minutes talk, and edited to reduce mathematical prerequisites and to emphasize the practical uses for the average programmer, as a talk in the weekly talk seminar for interns I ran about various interesting topics in computing science.	Microsoft Campus, Redmond
	2015	HONOURS COMPUTING SCIENCE SEMINAR Category Theory and its relation to Computing Science an hour-long talk introducing the subject to Honours computing scientists and emphasizing its relation to the Curry Howard isomorphism.	University of Alberta
	2014	NLP RESEARCH GROUP Cognates for Reconstruction of Native American Language groups a 20 minute talk emphasizing my work over the summer and explaining the organization method and SVM classification method for identifying cognates.	University of Alberta
	2013	RLAI TEA TIME TALKS Room Abstraction in Sokoban a 15 minute talk introducing the game of Sokoban, its combinatorial issues, and room abstraction as an aid to attacking the game.	University of Alberta

Experience

Selected Mathematical Knowledge (Including Textbooks Read)

FUNCTIONAL ANALYSIS

- Banach Spaces (Conway, Lax)
- Weak Topologies & Distribution Theory (Rudin)
- Operator Algebras (Kadison & Ringrose)

COMPLEX ANALYSIS

- Complex Variables (Ahlfors, Stein & Sharkarchi Vol. 2)
- Modular Forms (Milne, Diamond & Shurman)
- Riemann Surfaces (Gunning)

HARMONIC ANALYSIS

- Euclidean Harmonic Analysis (Stein & Sharkarchi Vol. 1, Körner, Stein & Weiss)
- Abstract Harmonic Analysis (Folland, Rudin, Hewit & Ross)
- Partial Differential Equations (Evans)
- Applications to Geometric Measure Theory (Mattila: Fourier Anal...)

ALGEBRA

- Galois Theory (Stewart, Lang: Algebra Chapters 4-6)
- Lie Algebras (Erdmann & Wildon, Hall, Fulton & Harris: Part 4)
- K Theory (Milnor, Adams)

TOPOLOGY

- Topology (Munkres)
- Algebraic Topology (Hatcher)
- Differential Topology (Bott & Tu, Tu: Diff. Geometry and Characteristic Classes)

DISCRETE MATHEMATICS

- Combinatorial Optimization (Korte & Vygen)
- Fourier Analysis of Boolean Functions (O'Donnell)
- Analytic Number Theory (Montgomery & Vaughn Vol. 1)

PROBABILITY THEORY

- Stochastic Processes (Lawler)
- Machine Learning (Hastie & Tibshirani)
- Reinforcement Learning (Sutton & Barto, Szepesvari)
- Multi Armed Bandits (Szepesvari & Lattimore)
- Brownian Motion and Stochastic Integration (Rogers & Williams Vol. 1)

GEOMETRY

- Riemannian Geometry (Lee: Riemannannian Man. and an Intro. to Curvature)
- Algebraic Geometry (Fulton: Algebraic Curves, Harris: A First Course)
- Projective Geometry (Richter-Gebert)

LOGIC AND THEORETICAL COMPUTING SCIENCE

- Mathematical Logic (Mendelson)
- Nonstandard Logic (Bimbo: Proof Theory & Generalized Galois Logics)
- Algorithms (Cormen & Leiserson & Rivest & Stein)
- Non Procedural Models of Computation (Hindley & Selden)
- Computability Theory (Sipser, Arora & Barak)

Research Projects

- 2017-2019 UNIVERSITY OF BRITISH COLUMBIA Vancouver, Canada
Masters Research Student
Worked with methods of geometric measure theory with Malabika Pramanik and Joshua Zahl in the harmonic analysis group at the University of British Columbia. Here we came up with novel techniques for constructing high dimensional fractals avoiding patterns. By employing a Cantor set type construction method, we were able to reduce the problem of avoiding patterns to the discrete problem of finding certain specialized independent sets in hypergraphs.
- 2017 UNIVERSITY OF ALBERTA Edmonton, Alberta
Undergraduate Research Assistant
Worked with combinatorial optimization researcher Zachary Friggstadt to come up with novel techniques for approximation algorithms to variants of the capacitated vehicle routing problem. We used Lagrangian preserving approximations for linear programming relaxations of the problem to obtain solutions to vehicle routing problems with cardinality requirements.
- 2014 UNIVERSITY OF ALBERTA Edmonton, Alberta
Natural Language Processing and Cognate Identification
Worked with the NLP group at the University of Alberta to develop cognate recognition algorithms. Successfully pushed to create a centralized database for storing cognate information, simplifying the learning process. This program was successfully used by linguists at the University of Alberta to understand the Totonac language group. Garrett Nicolai supervised the project (Nicolai@ualberta.ca).
- 2013 UNIVERSITY OF ALBERTA Edmonton, Alberta
Reinforcement Learning GAMES group
Implemented efficient abstraction algorithms to create a Sokoban solver for the RLAI group at the University of Alberta, under mentor Harm Van Seijen (Harm.Van.Seijen@gmail.com).

Summer Internships

- 2016 MICROSOFT Redmond, Washington
Universal Store Mobile Device Forensics
Developed algorithms for the mobile section of the Microsoft fraud detection team, which uses machine learning techniques on large data sets to predetermine fraud and protect the accounts of Microsoft store customers. The software I designed is set to be implemented on the two most popular Microsoft phone applications.
- 2015 MICROSOFT Redmond, Washington
Universal Store Spell Correction
Developed algorithms for data linkage. Utilizing various data-cleansing methods together with the Azure and Bing data-analysis packages, cleansed Microsoft's business partner database, removing redundant info, reducing database entries by 20%. My manager for this project was Aman Kansal (Kansal@microsoft.com). I also worked off-hours with a group of interns to send robot adventurers around the world (<http://www.projectatlas.ms/>), and organized weekly talk sessions!

Teaching Assistantships

2018	UNIVERSITY OF BRITISH COLUMBIA 'Introduction to Probability' Teaching Assistant Lead office hours and marked assignments on a first year course in probability.	Vancouver, Canada
2018	UNIVERSITY OF BRITISH COLUMBIA 'Introduction to Discrete Mathematics' Teaching Assistant Advised students while leading office hours and marking assignments on basic combinatorics, including basic counting methods, asymptotics, graph theory, and generating function techniques.	Vancouver, Canada
2017	UNIVERSITY OF BRITISH COLUMBIA Teaching Assistant to Two Calculus Courses Lead Workshops helping and testing students on the basic concepts of first semester calculus. Helped marked weekly assignments, midterms, and finals.	Vancouver, Canada
2015	UNIVERSITY OF ALBERTA 'Tangible Introduction To Computing Science' Teaching Assistant Advised students in the honours stream of Computing Science who were taking CMPUT 275, a class which introduced students to basic algorithmics, such as asymptotic analysis, divide and conquer, dynamic programming, and such. Led office hours weekly and marked assignments.	Edmonton, Alberta