JacobDenson

Mathematics Student

Research Interests

Harmonic Analysis, Geometric Measure Theory, Additive Combinatorics.

Contact Information

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Stack Overflow: jacob-denson

Website: 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.

Talks[1]

2018 — CMS WINTER MEETING & MAAM 2018 — CMS & University of Virginia

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.

2018 — DIFFERENTIAL TOPOLOGY CLASS — University of British Columbia

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.

2018 — MODULAR FORMS CLASS — University of British Columbia

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.

2018 — TOPICS IN HARMONIC ANALYSIS CLASS — University of British Columbia

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".

[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 — University of British Columbia
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.

2016 NONCOMMUTATIVE HARMONIC ANALYSIS CLASS — University of Alberta, 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.

2016 NONCOMMUTATIVE HARMONIC ANALYSIS CLASS — University of Alberta, 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 Pontrayagin duality.

2016 CUMC CONFERENCE — University of Victoria, Vancouver Island
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.

2016 ALGEBRAIC TOPOLOGY GRAUATE CLASS — University of Alberta, Canada
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.

2015 MICROSOFT INTERN TALKS — Microsoft Campus, Redmond
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 inerns I ran about various interesting topics in computing science.

2015 HONOURS COMPUTING SCIENCE SEMINAR — University of Alberta
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.

2014 NLP RESEARCH GROUP — University of Alberta
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.

2013 RLAI TEA TIME TALKS — University of Alberta
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.

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 (Cormer & 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 UNVERSITY OF BRITISH COLUMBIA Vancouver, Canada
'Introduction to Probability' Teaching Assistant
Lead office hours and marked assignments on a first year course in probability.

2018 UNIVERSITY OF BRITISH COLUMBIA Vancouver, Canada
'Introduction to Discrete Mathematics' Teaching Assitant
Advised students while leading office hours and marking assigments on basic combinatorics, including basic counting methods, asymptotics, graph theory, and generating function techniques.

2017 UNIVERSITY OF BRITISH COLUMBIA Vancouver, Canada
Teaching Assitant 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.

2015 UNIVERSITY OF ALBERTA Edmonton, 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.