Nicholas Barnfield

Department of Statistics
Harvard University
29 Oxford Street, Cambridge, MA 02138 nbarnfield@g.harvard.edu

Research interests

I am studying theoretical problems in high-dimensional probability theory with applications in machine learning. Currently, I am trying to understand when machine learning models can emulate state-of-the-art algorithms — opening a new paradigm for algorithm discovery with AI. Previously during my undergraduate studies, I spent considerable time examining entropic estimation algorithms in information theory where I succeeded in proving novel results in the field.

Education

Doctor of Philosophy August 2024 - (expected) May 2029

Statistics
Harvard University

Bachelor of Arts August 2021 - May 2024

Honours Probability and Statistics — Minor in Computer Science
GPA: 3.97
McGill University

Publications, Preprints, and Conference Proceedings

N. Barnfield, H. Cui, Y.M. Lu. *High-dimensional analysis of single-layer attention for sparse-token classification*. Submitted to the International Conference on Learning Representations (2025).

T. Chuna, N. Barnfield, et al. *Estimates of the dynamic structure factor for the finite temperature electron liquid via analytic continuation of path integral Monte Carlo data*. Physical Review B (2025).

T. Chuna, N. Barnfield, et al. *Dual formulation of the maximum entropy method applied to analytic continuation of quantum Monte Carlo data*. Journal of Physics A: Mathematical and Theoretical (2025).

N. Barnfield, R. Grondin, G. Pozzoli and R. Raquépas. *Ziv-Merhav estimation for hidden-Markov processes*. IEEE International Symposium on Information Theory (2024).

N. Barnfield, R. Grondin, G. Pozzoli and R. Raquépas. *On the Ziv-Merhav theorem beyond Markovianity II: A thermodynamic approach*. Submitted to the Annals of Applied Probability (2024).

N. Barnfield, R. Grondin, G. Pozzoli and R. Raquépas. *On the Ziv-Merhav theorem beyond Markovianity I*. Canadian Journal of Mathematics (2023).

Research Experience

Undergraduate Researcher Summer 2024
McGill University

Conducted research in mathematical optimization to develop an algorithm suitable for solving a signal-recovery problem involving entropic regularization terms. The theoretic work was motivated by diverse applications in physics, particularly in quantum field theory.

Undergraduate Researcher Summer 2023
McGill University – CY Advanced Studies Institute, Neuville-sur-Oise (France)

Worked on generalizing a result of Ziv and Merhav regarding the convergence to the specific cross-entropy of a sequential parsing algorithm for sequence pairs. This work culminated in an extension to suitably regular g-measures arising in dynamical systems and irreducible hidden-Markov measures with finite hidden state space.

Undergraduate Researcher Summer 2022
McGill University – CY Advanced Studies Institute, Neuville-sur-Oise (France)

Conducted research in entropic information theory under the supervision of Professor Vojkan Jakšić of McGill University and Dr. Renaud Raquépas of NYU. Studied how recurrences and waiting times can be used to estimate entropic quantities of sequences generated by shift-invariant probability measures.

Invited Talks

Convex and Nonconvex Nonsmooth Optimization and Applications June 2, 2026
SIAM Conference on Optimization, Edinburgh
A Self-Scaling Dual Method for Entropy-Regularized Least Squares

Séminaire Doctorant January 15, 2024
Laboratoire de Mathématiques de Besançon, Besançon
On the Ziv–Merhav theorem beyond Markovianity

The Seminars on Undergraduate Mathematics in Montreal January 6, 2024
Université du Québec à Montréal (UQÀM), Montréal
Entropic estimators in information theory

Mini-workshop on Entropies for Complex processes December 9, 2023
Mathematical Institute of the Serbian Academy of Sciences and Arts, Belgrade
Return times and waiting times as entropy estimators III: Ziv–Merhav Estimator

Recent Progress in Statistical Mechanics December 2, 2023
Winter Meeting of the Canadian Mathematical Society, Montréal
On the Ziv–Merhav theorem beyond Markovianity

Undergraduate Research Conference August 18, 2022
McGill University
Estimating entropic quantities using recurrences and waiting times

Awards and Distinctions

Master's Training Scholarship 2024-2026
Fonds de Recherche Québec, Nature et Technologie (FRQNT)

Undergraduate Student Research Awards (USRA) 2022, 2023, 2024
Natural Sciences and Engineering Research Council of Canada (NSERC)

Faculty of Arts Scholarship 2023
Faculty of Arts, McGill University

Dean's Honour List 2022, 2023
McGill University

MacLean Murray Scholarship 2022
Faculty of Arts, McGill University

Additional Skills

High Proficiency in French

Programming Knowledge
Python, Matlab, C++, R (decreasing order of proficiency)

Other Relevant Experience

Teaching Fellow Fall 2025
Probability 1 (graduate course)
Harvard University

Teaching/Course Assistant Fall 2022 - Fall 2024
Honors Applied Linear Algebra, Honors Analysis I, and Honors Analysis III
McGill University