Nicholas M. Boffi: Curriculum Vitae

Department of Mathematical Sciences
Carnegie Mellon University
Pittsburgh, PA 15289

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https://nmboffi.github.io

Education

Harvard University 2015–2021

Ph.D. Applied Mathematics
Advisors: Jean-Jacques E. Slotine (MIT) and Chris H. Rycroft (Harvard)
Thesis title: *Methods for scientific simulation, machine learning, and nonlinear control*

Northwestern University 2010-2014

B.A. Mathematics, Physics, and Integrated Science *with honors*
Advisor: Tamar Seideman
Thesis title: *High harmonic generation from simple aromatic molecules*

Professional Positions

Carnegie Mellon University 2024–present

Assistant Professor of Mathematics and Machine Learning (affiliated)

Courant Institute of Mathematical Sciences 2021–2024

Courant Instructor / Asssistant Professor

Google Brain 2020-2021

Research Intern / Student Researcher
Advisor: Vikas Sindhwani

Massachusetts Institute of Technology 2016-2021

Visiting Graduate Student Researcher
Advisor: Jean-Jacques Slotine

Lawrence Berkeley National Lab 2016

Computational Science Graduate Fellowship Practicum
Advisor: Adam Arkin

Tel Aviv University 2014–2015

Fulbright Research Scholar
Advisor: Amir Natan

Research Interests

Broadly: machine learning for high-dimensional computational mathematics

Specifically: generative modeling, dynamical transport of measure, stochastic thermodynamics, active matter, partial differential equations, adaptive control and learning, optimal control, dynamical systems, deep learning, optimization, numerical analysis, elasticity, continuum mechanics, electronic structure

Honors and Awards

NSF Postdoctoral Fellowship in the Mathematical Sciences, *declined* 2021

Harvard University Certificate of Distinction in Teaching 2016

Department of Energy Computational Science Graduate Research Fellowship 2015-2019

Fulbright Research Fellowship	2014
Honorary Cambridge Trust Fellowship, *declined*	2014
University of Chicago McCormick Fellowship, *declined*	2014
Cornell Graduate Fellowship, *declined*	2014
Phi Beta Kappa, Northwestern Chapter	2014
Hypercube Award for excellence in theoretical chemistry research, Northwestern University	2013
Fletcher Undergraduate Research Award, Northwestern University, *Finalist*	2012

Preprints

Nicholas M. Boffi*, Michael S. Albergo*, and Eric Vanden-Eijnden. Flow Map Matching. *arXiv:2406.07507*, 2024.

Nanye Ma, Mark Goldstein, Michael S. Albergo, Nicholas M. Boffi, Eric Vanden-Eijnden, and Saining Xie. SiT: Exploring Flow and Diffusion-based Generative Models with Scalable Interpolant Transformers. *arXiv:2401.08740*, 2024.

Michael S. Albergo*, Nicholas M. Boffi*, and Eric Vanden-Eijnden. Stochastic Interpolants: A Unifying Framework for Flows and Diffusions. *arXiv:2303.08797*, 2023.

Publications

Yifan Chen, Mark Goldstein, Mengjian Hua, Michael S. Albergo, Nicholas M. Boffi, and Eric Vanden-Eijnden. Probabilistic forecasting with stochastic interpolants and Föllmer processes. In *International Conference on Machine Learning*, 2024.

Michael S. Albergo, Mark Goldstein, Nicholas M. Boffi, Rajesh Ranganath, and Eric Vanden-Eijnden. Stochastic interpolants with data-dependent couplings. In *International Conference on Machine Learning*, 2024.

Nicholas M. Boffi and Eric Vanden-Eijnden. Deep learning probability flows and entropy production rates in active matter. *Proceedings of the National Academy of Sciences*, 121(25):e2318106121, June 2024.

Michael Samuel Albergo, Nicholas M. Boffi, Michael Lindsey, and Eric Vanden-Eijnden. Multimarginal generative modeling with stochastic interpolants. In *International Conference on Learning Representations*, 2024.

Nicholas M. Boffi, Yipei Guo, Chris H. Rycroft, and Ariel Amir. How microscopic epistasis and clonal interference shape the fitness trajectory in a spin glass model of microbial long-term evolution. *eLife*, 12, 2023.

Nicholas M. Boffi and Eric Vanden-Eijnden. Probability flow solution of the Fokker–Planck equation. *Machine Learning: Science and Technology*, 4(3):035012, 2023.

Saminda Abeyruwan, Alex Bewley, Nicholas M. Boffi, Krzysztof Marcin Choromanski, David B D'Ambrosio, Deepali Jain, Pannag R Sanketi, Anish Shankar, Vikas Sindhwani, Sumeet Singh, Jean-Jacques Slotine, and Stephen Tu. Agile catching with whole-body mpc and blackbox policy learning. In *Proceedings of The 5th Annual Learning for Dynamics and Control Conference*, volume 211 of *Proceedings of Machine Learning Research*, pages 851–863, 2023.

Nicholas M. Boffi*, Stephen Tu*, and Jean-Jacques E. Slotine. Nonparametric adaptive control and prediction: theory and randomized algorithms. *Journal of Machine Learning Research*, 23(281):1–46, 2022.

Thomas Zhang, Stephen Tu, Nicholas M. Boffi, Jean-Jacques Slotine, and Nikolai Matni. Adversarially robust stability certificates can be sample-efficient. In *Proceedings of The 4th Annual Learning for Dynamics and Control Conference*, volume 168 of *Proceedings of Machine Learning Research*, pages 532–545, 2022.

Nicholas M. Boffi*, Stephen Tu*, and Jean-Jacques Slotine. The role of optimization geometry in single neuron learning. In *Proceedings of The 25th International Conference on Artificial Intelligence and Statistics*, volume 151 of *Proceedings of Machine Learning Research*, pages 11528–11549, 2022.

Nicholas M. Boffi*, Stephen Tu*, Nikolai Matni, Jean-Jacques Slotine, and Vikas Sindhwani. Learning stability certificates from data. In *Proceedings of the 2020 Conference on Robot Learning*, volume 155 of *Proceedings of Machine Learning Research*, pages 1341–1350, 2021.

Katiana Kontolati, Darius Alix-Williams, Nicholas M. Boffi, Michael L. Falk, Chris H. Rycroft, and Michael D. Shields. Manifold learning for coarse-graining atomistic simulations: Application to amorphous solids. *Acta Materialia*, 215:117008, 2021.

Nicholas M. Boffi*, Stephen Tu*, and Jean-Jacques Slotine. Nonparametric adaptive control and prediction: Theory and randomized algorithms. In *Proceedings of the 60th IEEE Conference on Decision and Control (CDC)*, pages 2935–2942, 2021.

Nicholas M. Boffi*, Stephen Tu*, and Jean-Jacques E. Slotine. Regret bounds for adaptive nonlinear control **(selected for oral presentation)**. In *Proceedings of the 3rd Conference on Learning for Dynamics and Control*, volume 144 of *Proceedings of Machine Learning Research*, pages 471–483, 2021.

Nicholas M. Boffi and Jean-Jacques E. Slotine. Implicit regularization and momentum algorithms in nonlinearly parameterized adaptive control and prediction **(featured on the cover)**. *Neural Computation*, 33(3):590–673, 2021.

Nicholas M. Boffi and Chris H. Rycroft. Coordinate transformation methodology for simulating quasistatic elastoplastic solids. *Physical Review E*, 101:053304, 2020.

Nicholas M. Boffi and Chris H. Rycroft. Parallel three-dimensional simulations of quasi-static elastoplastic solids. *Computer Physics Communications*, 257:107254, 2020.

Nicholas M. Boffi and Jean-Jacques E. Slotine. A continuous-time analysis of distributed stochastic gradient. *Neural Computation*, 32(1):36–96, 2020.

Nicholas M. Boffi, Manish Jain, and Amir Natan. Efficient computation of the Hartree–Fock exchange in real-space with projection operators. *Journal of Chemical Theory and Computation*, 12(8):3614–3622, 2016.

Nicholas M. Boffi, Manish Jain, and Amir Natan. Asymptotic behavior and interpretation of virtual states: The effects of confinement and of basis sets. *The Journal of Chemical Physics*, 144(8):084104, 2016.

Nicholas M. Boffi, Judith C. Hill, and Matthew G. Reuter. Characterizing the inverses of block tridiagonal, block Toeplitz matrices. *Computational Science & Discovery*, 8(1):015001, 2014.

Matthew G. Reuter, Nicholas M. Boffi, Mark A. Ratner, and Tamar Seideman. The role of dimensionality in the decay of surface effects. *The Journal of Chemical Physics*, 138(8):084707, 2013.

Software

Author of `active_probability_flows`, a method for learning physical probability flows 2024
https://github.com/nmboffi/active_pflows

Co-author of `stochastic-interpolants`, an implementation of the stochastic interpolant method 2023
https://github.com/malbergo/stochastic-interpolants

Author of `sbtm`, an implementation of the score-based transport modeling algorithm 2023
https://github.com/nmboffi/sbtm

Author of `spin_glass_evodyn`, a simulation of evolutionary dynamics via spin glass physics 2023
https://github.com/nmboffi/spin_glass_evodyn

Author of `stzpp`, a simulation of the shear transformation zone theory of amorphous plasticity 2021
https://github.com/nmboffi/stzpp

Contributor to `PARSEC`, a real-space electronic structure code 2015
http://real-space.org/

Teaching

Honors numerical analysis Spring 2024
Courant Institute of Mathematical Sciences, New York University
Instructor

Linear and nonlinear optimization Fall 2023
Courant Institute of Mathematical Sciences, New York University
Instructor

Linear and nonlinear optimization Spring 2023
Courant Institute of Mathematical Sciences, New York University
Instructor

Numerical analysis Fall 2022
Courant Institute of Mathematical Sciences, New York University
Instructor

Linear and nonlinear optimization Spring 2022
Courant Institute of Mathematical Sciences, New York University
Instructor

Numerical analysis Fall 2021
Courant Institute of Mathematical Sciences, New York University
Instructor

Advanced scientific computing: numerical methods II Spring 2021
Harvard University
Teaching Fellow

Learning, estimation, and control of dynamical systems Spring 2020
Harvard University
Teaching Fellow

Advanced scientific computing: numerical methods Fall 2019
Harvard University
Teaching Fellow

Advanced scientific computing: numerical methods Fall 2016
Harvard University
Teaching Fellow

Integrated Science Program 101 Full Academic Year 2013–2014
Northwestern University
Instructor

Integrated Science Program 101 Full Academic Years 2011–2013
Northwestern University
Teaching Assistant

Mentoring

Applied Mathematics Summer Undergraduate Research Experience (AM-SURE) 2022
Program coordinator, Courant Institute of Mathematical Sciences
Mentored ten undergraduate students through summer research projects

Jimmy Almgren-Bell 2017 – 2019
Senior thesis, Harvard University
Thesis title: *An agent-based numerical approach to Lenski's long-term evolution experiment*

Professional activities

Workshop organizer

Measure Transport, Diffusion Processes, and Sampling Dec. 4–6, 2023
Flatiron Institute, New York City
Jointly organized with Michael Albergo (NYU), Bob Carpenter (Flatiron Institute), Neha Wadia (Flatiron Institute), and Joan Bruna (Courant, Flatiron Institute)

Reviewer

Journal of Machine Learning Research, Proceedings of the National Academy of Sciences, Physica D: Nonlinear Phenomena, IEEE Transactions on Automatic Control, IEEE Systems & Control Letters, SIAM Journal on Mathematics of Data Science, Neural Information Processing Systems, International Conference on Learning Representations, International Conference on Machine Learning, AISTATS, Learning for Dynamics and Control

Selected Talks

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
Youth in High Dimensions Workshop, International Center for Theoretical Physics

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
CRUNCH Seminar, Brown University

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
Applied Mathematics Seminar, University of Washington

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
Applied and Interdisciplinary Mathematics Seminar, University of Michigan

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
Computational and Applied Mathematics Seminar, University of Chicago

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
Applied Mathematics Seminar, Massachusetts Institute of Technology

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2024
Mathematics Seminar, University of North Carolina

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2023
Center for Nonlinear Analysis Seminar, Carnegie Mellon University

On flows and diffusions: from many-body Fokker-Planck to stochastic interpolants 2023
Modeling and Simulation Seminar, Courant Institute of Mathematical Sciences

Deep learning probability flows and entropy production rates in active matter 2023
Generative Modeling Foundations, Courant Institute of Mathematical Sciences

Deep learning probability flows and entropy production rates in active matter 2023
Scientific Machine Learning Seminar, Courant Institute of Mathematical Sciences

Neural networks for computational mathematicians 2023
Modeling and Simulation Seminar, Courant Institute of Mathematical Sciences

A spin glass model of microbial long-term evolution 2023
Mostly Biomathematics Seminar, Courant Institute of Mathematical Sciences

On stochastic and deterministic generative models 2023
Generative Modeling Foundations, Courant Institute of Mathematical Sciences

Representation and optimization in adaptive control 2023
Azizan Group, Massachusetts Institute of Technology

Probability flow solution of the Fokker-Planck equation 2022
Google Brain Robotics, New York, New York

Probability flow solution of the Fokker-Planck equation 2022
Sampling, Transport, and Diffusions Workshop, Flatiron Institute

Probability flow solution of the Fokker-Planck equation 2022
Computational Mathematics Seminar, Courant Institute of Mathematical Sciences

Probability flow solution of the Fokker-Planck equation 2022
Generative Modeling Foundations, Courant Institute of Mathematical Sciences

Probability flow solution of the Fokker-Planck equation 2022
Bruna Group, Courant Institute of Mathematical Sciences

Nonparametric adaptive control: theory and randomized algorithms 2022
Courant Instructor Day, Courant Institute of Mathematical Sciences

A spin glass model of microbial long-term evolution 2021
Modeling and Simulation Seminar, Courant Institute of Mathematical Sciences

Nonlinear adaptive control theory: a view from optimization and machine learning 2021
Bruna Group, Courant Institute of Mathematical Sciences

Nonparametric adaptive control: theory and randomized algorithms 2021
CRAN, Université de Lorraine (Virtual)

Regret bounds for adaptive nonlinear control 2021
3rd Annual Conference on Learning for Dynamics and Control (Virtual)

Projection methods for quasi-static hypo-elastoplasticity 2021
Numerical Methods for PDEs Seminar, Massachusetts Institute of Technology

Projection methods for quasi-static hypo-elastoplasticity 2021
Modeling and Simulation Seminar, Courant Institute of Mathematical Sciences

Adaptive control theory 2021
Learning for Dynamics and Control Course, Google Brain (Virtual)

Learning stability certificates from data 2021
Anandkumar Group, California Institute of Technology

Learning stability certificates from data 2020
Neurophysics Group, Harvard University

A continuous-time analysis of distributed stochastic gradient 2020
Google Brain Robotics, New York, New York

Adaptive control and statistical learning 2020
Google Brain Robotics, New York, New York

Learning dynamical systems with deep feedforward and balanced recurrent networks 2020
Neurophysics Group, Harvard University

Parallel three-dimensional simulations of quasi-static elastoplastic solids 2019
Computational Science Graduate Fellowship Program Review, Arlington, Virginia

Continuum-level simulation of shear banding in metallic glasses on transforming grids 2019
American Physical Society March Meeting, Boston, Massachusetts

Three-dimensional continuum-level simulation of shear banding in metallic glasses 2018
American Physical Society March Meeting, Los Angeles, California

A quasi-static projection method for three-dimensional hypo-elastoplasticity 2017
SIAM Conference on Computational Science and Engineering, Atlanta, Georgia

Amorphous plasticity and the shear transformation zone theory 2016
Kavli Seminar, Harvard University