George Stepaniants

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I am an applied mathematician who studies how the partial, incomplete, and noisy data we collect from physical systems leads to degrees of freedom along which a physical model cannot be resolved. Across a wide range of problems concerning mechanics of materials, fluid flows, biophysical processes, and network dynamics, my goal is to develop mathematical theory and data-driven machine learning architectures that allow us to learn the maximal amount of information from such partially observed systems. My teaching philosophy is inspired by my research, showing students how to discover interesting mathematical ideas in field-specific literature, translate them into well-posed mathematical theories, and when possible, bring these theories to life as numerical algorithms.

Employment

Sep 2024 - Current — **California Institute of Technology (NSF Postdoctoral Scholar)**
NSF Mathematical Sciences Postdoctoral Research Fellow (MSPRF)
Department of Computing and Mathematical Sciences (CMS)
Postdoctoral Advisor: Andrew Stuart

Education

Sep 2019 - Jun 2024 — **Massachusetts Institute of Technology (PhD)**
GPA: 4.9/5.0
Department of Mathematics and Institute for Data, Systems, and Society (IDSS)
PhD Advisors: Philippe Rigollet and Jörn Dunkel
Graduate Thesis: *Inference from limited observations in statistical, dynamical, and functional problems*

Sep 2015 - Jun 2019 — **University of Washington (BSc)**
GPA: 3.87/4.00
Department of Mathematics and Department of Computer Science (double major)
Undergraduate Research Advisors: Nathan Kutz and Bing Brunton
Research Topic: *Inferring causal networks of dynamical systems through transient dynamics and perturbation*

Academic Awards

NSF Mathematical Sciences Postdoctoral Research Fellowship (MSPRF)	Sep 2024 - Current
IMS Lawrence D. Brown Ph.D. Student Award Recipient	Sep 2024
NSF Graduate Research Fellowship (GRFP)	Jun 2019 - Jun 2024
SIAM Student Travel Award	Dec 2023
Calouste Gulbenkian Foundation Short Term Conference and Travel Grant	Jun 2023
MIT Presidential Fellow	Sep 2019 - Jun 2020
Phi Beta Kappa Honors Society Member	Jun 2019
Mary Gates Research Scholarship (merit-based)	Jun 2019
University of Washington Dean's List	Sep 2015 - Jun 2019
Early acceptance to University of Washington at age 16 (UW Academy)	Sep 2015

Teaching Experience and Mentorship

California Institute of Technology - Mentorship

(MCM) Trained three teams for the Mathematical Competition in Modeling	Fall 2024

Massachusetts Institute of Technology - Teaching Assistant

(18.032) Differential Equations (theory focused)	Spring 2022
(18.600) Introduction to Probability	Fall 2021

Massachusetts Institute of Technology - Mentorship

(SPUR+) Trade and Tariff Network Dynamics	Summer 2023 - Fall 2023
(UROP) Network Inference and Optimal Transport	Summer 2023
(UROP) Optimal Transport for Protein Folding	Fall 2021 - Spring 2021

University of Washington - Community Service

Math tutoring from K12 to college-level subjects	2015 - 2019
Teaching assistant at University of Washington Math Circle	2015 - 2016

Service and Leadership

1. Organizing a panel for graduate school experience and research in Pasadena Armenian community 2024
2. Organized panel on graduate school experience and research in Redmond Armenian community 2020
3. Founded and led Armenian Student Association at the University of Washington (ASAUW) 2015 - 2019
4. Competition judge at the University of Washington Math Olympiad 2015 - 2019

Publications

Manuscripts in Review

- Yanjun Han, Philippe Rigollet, and George Stepaniants. "Covariance alignment: from maximum likelihood estimation to Gromov-Wasserstein." *arXiv preprint arXiv:2311.13595* (2023).

Journal Articles

- George Stepaniants, Alasdair D. Hastewell, Dominic J. Skinner, Jan F. Totz, and Jörn Dunkel. "Discovering dynamics and parameters of nonlinear oscillatory and chaotic systems from partial observations." *Phys. Rev. Res.* 6, 043062 (2024).
- Marie Breeur, George Stepaniants, Pekka Keski-Rahkonen, Philippe Rigollet, and Vivian Viallon. "Optimal transport for automatic alignment of untargeted metabolomic data." *eLife 12:RP91597* (2024).
- George Stepaniants. "Learning partial differential equations in reproducing kernel Hilbert spaces." *Journal of Machine Learning Research* 24.86 (2023): 1-72.
- George Stepaniants, Bingni W. Brunton, and J. Nathan Kutz. "Inferring causal networks of dynamical systems through transient dynamics and perturbation." *Physical Review E* 102.4 (2020): 042309.

Conference Proceedings

- Enric Boix-Adserà, Hannah Lawrence, George Stepaniants, and Philippe Rigollet. "GULP: a prediction-based metric between representations." *Advances in Neural Information Processing Systems* (2022).
- Sinho Chewi, Julien Clancy, Thibaut Le Gouic, Philippe Rigollet, George Stepaniants, and Austin Stromme. "Fast and smooth interpolation on Wasserstein space." *International Conference on Artificial Intelligence and Statistics*. PMLR (2021).

In Preparation

- A Hilbert transform approach for practical, closed-form time deconvolution
- Physical meaning of Prony series and internal variables in constitutive models of viscoelastic materials
- Learning memory effects in constitutive models as a function of the material microstructure

Talks and Presentations

Organized Symposia

- "Minisymposium on Data-Driven Learning of Dynamical Systems from Partial Observations", SIAM Conference on Mathematics of Data Science, Atlanta, October 2024

Invited Talks

- "Discovering dynamics and parameters of nonlinear oscillatory and chaotic systems from partial observations", Fourth Symposium on Machine Learning and Dynamical Systems, Fields Institute, July 2024
- "Covariance Alignment with Optimal Transport", Yale Applied Mathematics Seminar, New Haven, April 2024

- "Gromov-Wasserstein Theory and Application to Metabolomics", SIAM Conference on Uncertainty Quantification, Trieste, Italy, February 2024
- "Gromov-Wasserstein Theory and Application to Metabolomics", Statistics and Learning Theory Summer School, Tsaghkadzor, Armenia, July 2023 **(One of 7 invited speakers)**
- "Optimal transport for automatic alignment of untargeted metabolomic data", Harvard Applied Math Graduate Student Seminar, Cambridge, March 2023
- "Learning PDEs in a Reproducing Kernel Hilbert Space", SIAM Conference on Mathematics of Data Science, San Diego, September 2022
- "Learning PDEs in a Reproducing Kernel Hilbert Space", Meeting on Mathematical Statistics, CIRM, Marseille, France, December 2021 **(Only 3 graduate student speakers invited)**

Contributed Talks

- "Discovering dynamics and parameters of nonlinear oscillatory and chaotic systems from partial observations", Dynamics Days, UC Davis, January 2024
- "Learning and predicting complex systems dynamics from single-variable observations", APS March Meeting, Chicago, March 2022
- "Learning PDEs in a Reproducing Kernel Hilbert Space", LIDS Stats & Tea, MIT, December 2021
- "Inferring causal networks of dynamical systems through transient dynamics and perturbation", Econometrics Lunch, MIT, December 2021
- "Fusion of Genetically Incompatible Fungal Cells", UCLA Computational and Applied Math REU Presentation, IPAM, August 2018
- "Quantifying Rupture Risk of Brain Anuerysms", MATDAT18: NSF Materials and Data Science Hackathon, Alexandria, June 2018
- "Hyperparameter Selection", AI2 Research Internship Final Presentation, Seattle, August 2017
- "Beaker Experimentation Platform", AI2 Research Internship Midterm Presentation, Seattle, August 2017
- "Image Analysis in Parkinson's Research", Pfizer Research Internship Final Presentation, Cambridge, August 2016

Poster Presentations

- "Covariance alignment: from maximum-likelihood estimation to Gromov-Wasserstein", Cornell ORIE Young Researchers Workshop, Cornell, October 2023
- "Inferring causal networks of dynamical systems through transient dynamics and perturbation", Undergraduate Research Symposium, UW, June 2019

Internship and Research Experience

Jul 2018 - Aug 2018 | Computational and Applied Math **Research Experience for Undergrads (REU) at UCLA**

Undergraduate Researcher in Mycofluidics Lab

Worked in Professor Marcus Roper's lab on imaging of fungal cells in *Neurospora* and *Ashbya* fungal species. Collected data on nuclear division of these multinucleated cells using 3D imaging algorithms and performed data analysis on nuclear spacing and mixing within the cell. Discovered that genetically incompatible fungal strains fuse together when exposed to environmental stress. We are working on a paper that relies on the research findings and imaging algorithms I developed at UCLA.

Jun 2017 - Sep 2017 | Engineering Intern at **Allen Institute for Artificial Intelligence (AI2)**

Full Stack Development and Data Analysis/Visualization

Collaborated with researchers and built a system which optimized hyperparameter selection in various neural network experiments ran in the company. I was responsible for experiment design decisions in the company and execution of these experiments on a Google cluster. My platform significantly simplified the experimentation process and reduced the runtime by a factor of two.

Aug 2016 - Dec 2016 | Natural Language Processing Intern at **ABBYY**

Parser Accuracy Scoring

Compared ABBYY's parser efficiency and output to that of MaltParser. Created scripts in Java to read parser output from CoNLL-X data files and scored them using an unlabeled and labeled attachment score (UAS and LAS). Used Excel for visual and graphing purposes.

Jun 2016 - Aug 2016 | Image Analysis Intern at **Pfizer**

Imaging Algorithms for Automated Brain Slice Imaging

Worked in Neuroscience Pain Research Unit (NPRU) at Pfizer. Studied how various drugs help regenerate healthy cells damaged by neurodegenerative diseases, especially Parkinson's. Used image analysis algorithms, 3D Watershed Segmentation in particular, to quantify the percentage of regenerated healthy cells after treatment. My automated imaging pipeline was used by researchers to quantify **hundreds** of drug profiles and reduced the runtime of their image analysis code by **10 times**.