Forest Kobayashi

Contact Information

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He/him/his

Citizenship USA (Alaska)

Languages English (native), Mandarin Chinese (intermediate), Japanese (intermediate)

Research Interests Optimization problems in stochastic/statistical contexts; Calculus of variations; Optimal transport; Mathematical theory of machine learning; Computational methods

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Education

University of British Columbia, Vancouver, British Columbia.
Ph.D. in Mathematics (2020-2025).
Advisor: Young-Heon Kim.
Dissertation: Optimal transport approximation of measures via lower-dimensional structures: principal manifolds and the average distance problem.

Harvey Mudd College, Claremont, California.
B.S. in Mathematics (2016-2020). High Distinction; Honors in Mathematics.
Thesis: *Where the Wild Knots Are*. Advisor: Francis Su
Secondary concentration: Art.

Other Affiliations

Research Visits:

- (April–May 2025) Visiting Graduate Student, *Université Paris-Saclay + Université Paris-Dauphine*, PARMA + MOKAPLAN groups.

Past:

- (Summer 2019) Research Assistant, *Harvey Mudd College*, Knot Theory.
- (Summer 2018) Research Intern, *UnifyID*, Machine Learning + Data Science.
- (Summer 2017) Research Assistant, *Harvey Mudd College*, CS Education.
- (Summer 2015) Lab Assistant, *University of Hawai'i Mānoa*, Phylogenetics.

Preprints and Publications (link)

[1] L. O'Brien, F. Kobayashi, and Y.-H. Kim, "Structure of average distance minimizers in general dimensions," *arXiv*, Mar. 2025. DOI: 10.48550/arXiv.2503.23256. eprint: 2503.23256.

[2] A. Warren, A. Afanassiev, F. Kobayashi, Y.-H. Kim, and G. Schiebinger, "Principal Curves In Metric Spaces And The Space Of Probability Measures," *arXiv*, May 2025. DOI: 10.48550/arXiv.2505.04168. eprint: 2505.04168.

[3] F. Kobayashi, J. Hayase, and Y.-H. Kim, "Monge-Kantorovich Fitting With Sobolev Budgets," *arXiv*, Sep. 2024. DOI: 10.48550/arXiv.2409.16541. eprint: 2409.16541.

[4] F. Kobayashi, "Uniform Convergence and Knot Equivalence," *arXiv*, Jan. 2021. DOI: 10.48550/arXiv.2101.04106. eprint: 2101.04106.

[5] F. Kobayashi and S. Nelson, "Kaestner brackets," *Topology Appl.*, vol. 282, p. 107 324, Aug. 2020, ISSN: 0166-8641. DOI: 10.1016/j.topol.2020.107324. arXiv: 1909.09920 [math.GT].

[6] M. Zug, H. Hoffman, F. Kobayashi, M. President, and Z. Dodds, "CS for all academic identities," *J. Comput. Sci. Coll.*, vol. 33, no. 4, pp. 130–137, Apr. 2018, ISSN: 1937-4771. [Online]. Available: http://dl.acm.org/citation.cfm?id=3199572.3199590.

Professional Service

- Refereed for: SIAM Journal on Mathematical Analysis

Illustration

- TikZ illustration work featured in Starbird & Su's *Topology Through Inquiry*. >20 technical diagrams, including two featured as cover art.

Presentations

Conference Talks

- *Monge-Kantorovich Fitting Under a Sobolev Budget.* Presented at:
  - (Invited) Jan. 2025, Joint Mathematics Meetings CRM-PIMS-AARMS Special Session on Optimal Transport.
  - (Invited) Aug. 2024, Kantorovich Initiative Retreat.
  - (Contributed) Jul. 2024, SAARC Summer School on Optimal Transport, Stochastic Analysis and Applications to Machine Learning.
- Kaestner Brackets. (Contributed) Jul. 2019, UnKnot IV.

Seminar Presentations

- *Two Problems in Approximating Measures by Lower-Dimensional Sets*
  - (28 Apr. 2025) OT-ML-PDE seminar, University Paris-Saclay, Orsay, France.
- *Constrained Wasserstein Fitting.*
  - (15 Nov. 2023) Bae Myoung-Jean's research group seminar, KAIST, ROK.
  - (14 Nov. 2023) Kang Moon-Jin's research group seminar, KAIST, ROK.
- *On Performing Countably-many Reidemeister Moves*.
  - (23 Apr. 2021) UBC Mathematics Graduate Seminar.

Summer Schools

- (2024) SAARC Summer School on Optimal Transport, Stochastic Analysis and Applications to Machine Learning. KAIST, ROK.
- (2022) SLMath (formerly *MSRI*) Metric Geometry and Geometric Analysis Graduate Summer School. Oxford University, UK.
- (2022) PIMS-IFDS-NSF Summer School on Optimal Transport. University of Washington, USA.
- (2021) Durham Days of Analysis and PDE. Online.

Misc.

- (Oct.–Nov. 2023) Visiting Researcher, *Korea Advanced Institute of Science and Technology (KAIST)*. Visited Young-Heon Kim (advisor) during his sabbatical.
- (2023) Kantorovich Initiative + Scale MoDL Retreat. University of Washington, USA.
- (2023) IFML + Kantorovich Initiative Retreat. University of Washington, USA.
- (2022) Kantorovich Initiative Retreat. University of Washington, USA.

Honors, Awards, and Prizes

Graduate:

- (2020-2024) *UBC Four Year Doctoral Fellowship.*
- (Declined for PhD studies in Canada) *NSF Graduate Research Fellowship.*

Undergraduate:

- (2020) *The Greever Research Prize*, Harvey Mudd College.
- (2020) *Outstanding Poster*, JMM 2020.
- (2019-2020) *Giovanni Borrelli Mathematics Fellowship*, Harvey Mudd College.
- (2019) *Best Poster*, Claremont Center for the Mathematical Sciences.
- (2019) *First Place Team.* Google Tech Challenge Orange County (regional inter-collegiate puzzlehunt and speed-coding competition).
- (2016-2020) *Harvey S. Mudd Merit Award.*

Programming Skills

Programming Languages: experienced with Julia, Python; working knowledge in bash, zsh; prior experience with Maple, Rust, Mathematica, MATLAB, SWI-Prolog, R, and Haskell.

Software & Libraries: expert in TikZ; experienced with LaTeX, Arch Linux, git, NumPy, Emacs, jupyter, various Julia libraries; working knowledge in selenium, Vim, matplotlib, pandas

Selected Programming Projects:

- SobolevPrincipalCurves.jl: Joint work with Jonathan Hayase. A fast Julia implementation of our algorithm from [3] with some improvements/generalizations that will be detailed in a forthcoming work.
- Contributor to Plom, a free-and-open-source alternative to crowdmark/gradescope/speedgrader alternative that is in ongoing development at UBC. Among other things, I created an interface between Plom and Canvas that enables pulling submissions directly from Canvas into Plom, as well as subsequent push-back of graded work.
- linear-presentation: Joint work with Jonathan Hayase. A Python program for converting signed Gauss codes into knot diagrams in which all crossings are colinear. Works for both virtual and classical knots. Algorithm abstracts the strand-routing process as pushing symbols between two stacks, bringing runtime down to $O(n)$ (where n is the length of the desired output diagram). Thus the performance is provably optimal up to a constant.
- birack-lib: A Python package for fast enumeration of the birack-flavored knot invariants we introduced in [5]. On certain inputs, improved runtime performance relative to previous methods by 6 orders of magnitude. Also includes some Julia scripts to search for infinite familes of such invariants embedded into polynomial rings.
- svg-to-tikz: A lightweight transpiler for converting .svg images (e.g., Inkscape drawings) into TikZ code.
- Conway-k-regular: a Python implementation of Conway's game of life on a non-uniform tiling of convex polygons.
- barnes-rust: A Rust-implemented Barnes-Hut n-body simulator.

Teaching

Teaching:

- (Spring 2026) Honors Engineering Calculus II, instructor
- (Spring 2025) Calculus, small class instructor
- (Fall 2021 – Spring 2023) Differential Calculus, workshop instructor

Grading + TAing:

- (Fall 2023 – Fall 2024) Intro Calculus Piazza TA
- (Fall 2020 – Spring 2021) Linear Programming TA
- (Spring 2019) Topology TA (Inquiry-Based Learning)
- (Fall 2017) Discrete Mathematics
- (Spring 2017) Intro to Computer Science

Other TAing:

- (Spring 2021 – Spring 2025) `Plom` TA. I run logistics as well as the scanning/grading software for large exams in the UBC Math Department (plus a few in the Biology department). Designed a new workflow that facilitated full ingestion of Math 100/101 exams ($\approx$ 180 reams of paper) in just 18 hours, roughly a 2$\times$ speedup.

Undergrads Mentored

- Lucas O'Brien (Summer 2024; [1])

Outreach

- (Summer 2020) CyberMath Tutor
  - Tutored a group of 4 students in math concepts 2$\times$ per week in 3 hour sessions.
- (Spring 2019) Gateway to Exploring Mathematical Sciences Volunteer
  - TAed a workshop introducing 8-10$^{\text{th}}$ grade students to concepts in Graph Theory.

Other

Music:

- >24 years of Violin experience, including 6 years of chamber music and 4 years of orchestra.

Art:

- Various Photography gigs
- Independent study with Ken Fandell.
- Delivered a $\approx$ 10 min talk to the trustees of Harvey Mudd College about Art in the student experience (Spring 2019)

Misc:

- Ordained to officiate weddings in the state of Washington. One happily-married couple so far!

References

Research:

Young-Heon Kim (yhkim@math.ubc.ca)
Professor, Department of Mathematics, University of British Columbia

Dejan Slepčev (slepcev@math.cmu.edu)
Professor, Department of Mathematical Sciences, Carnegie Mellon University

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Postdoctoral Fellow, Department of Mathematics, University of British Columbia

Programming:

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Teaching:

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