DHANANJAY BHASKAR

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RESEARCH INTERESTS

Mathematical & Computational Biology, Topological Data Analysis, Manifold Learning, Geometric Deep Learning, Dynamical Systems, Agent-Based Modeling

APPOINTMENTS

Yale University, New Haven, CT, USA **Jun 2021 - Present**

Postdoctoral Research Associate
Yale - Boehringer Ingelheim Biomedical Data Science Fellow
Executive Board Member, Yale Postdoctoral Association
Advisor: Prof. Smita Krishnaswamy

Brown University, Providence, RI, USA **Jun 2021 - Present**

Visiting Scholar in Engineering

EDUCATION

Brown University, Providence, RI, USA **May 2021**

Ph.D. - Biomedical Engineering
Sc.M. - Data Science
Dissertation: Topological Data Analysis of Collective Motion
Advisor: Prof. Ian Y. Wong

University of British Columbia, Vancouver, BC, Canada **May 2017**

M.Sc. - Institute of Applied Mathematics
Dissertation: Morphology-Based Cell Classification: Unsupervised Machine Learning Approach
Advisor: Prof. Leah Edelstein-Keshet

University of British Columbia, Vancouver, BC, Canada **May 2015**

B.Sc. - Combined Major in Computer Science & Mathematics (with distinction)

HONORS AND AWARDS

- Outstanding Contribution Award, Yale Postdoctoral Association **2023**
- DAAD AINeT Fellowship for Generative Models in Machine Learning **2023**
- Yale - Boehringer Ingelheim Biomedical Data Science Fellowship **2021 - 2024**
- Brown Data Science Initiative Seed Grant **2020**
- AMS MRC Collaborative Research Travel Grant **2019**
- E Paul Sorensen Graduate Fellowship, Brown University **2017**
- Faculty of Science Graduate Award, UBC **2016**
- The Tenth q-bio Summer School Scholarship **2016**
- International Tuition Scholarship, UBC **2015 - 2016**
- International Undergraduate Summer Research Award, UBC **2014**

PUBLICATIONS

16. **A flow artist for high-dimensional cellular data**, Macdonald, K.*, Bhaskar, D.*, Thampakkul, G., Nguyen, N., Zhang, J., Perlmutter, M., Adelstein, I., & Krishnaswamy S. *Proceedings of the IEEE 33rd International Workshop on Machine Learning for Signal Processing (MLSP)*, Rome, Italy, pp. 1-6, 2023.
15. **Topological data analysis of spatial patterning in heterogeneous cell populations: clustering and sorting with varying cell-cell adhesion**, Bhaskar, D., Zhang, W., Volkening, A., Sandstede, B., & Wong I. *npj Systems Biology and Applications* 9 (1), 43, 2023.

PUBLICATIONS *(Cont'd)*

14. **Multiscale geometric and topological analyses for characterizing and predicting immune responses from single cell data**, Venkat, A., Bhaskar, D., & Krishnaswamy, S. *Trends in Immunology* 44, 551-563, 2023.
13. **Cell cycle controls long-range calcium signaling in the regenerating epidermis**†, Moore, J.⋆, Bhaskar, D.⋆, Gao, F., Matte-Martone, C., Du, S., Lathrop, E., Ganesan, S., Shao, L., Norris, R., Sanz, N., Annusver, K., Kasper, M., Cox, A., Hendry, C., Rieck, B., Krishnaswamy, S., & Greco, V. *J Cell Biol* 222 (7), e202302095, 2023.
12. **Diffusion curvature for estimating local curvature in high dimensional data**, Bhaskar, D., MacDonald, K., Fasina, O., Thomas, D., Rieck, B., Adelstein, I., & Krishnaswamy S. *Advances in Neural Information Processing Systems* 35, 21738-21749, 2022.
11. **Transformer-based protein generation with regularized latent space optimization**, Castro E., Godavarthi A., Rubinfien J., Givechian K., Bhaskar, D.‡, & Krishnaswamy, S.‡ *Nature Machine Intelligence* 4, 840-851, 2022.
10. **Molecular graph generation via geometric scattering**, Bhaskar, D., Grady, J., Castro, E., Perlmutter, M., & Krishnaswamy, S. *Proceedings of the IEEE 32nd International Workshop on Machine Learning for Signal Processing (MLSP)*, Xi'an, China, pp. 1-6, 2022.
9. **Current trends in artificial intelligence in reproductive endocrinology**, Bhaskar, D., Chang, T., & Wang S. *Current Opinion in Obstetrics and Gynecology*, 34 (4), 159-163, 2022.
8. **The need for speed: Migratory cells in tight spaces boost their molecular clock**, Bhaskar, D., Hruska, A., & Wong, I. *Cell Systems*, 13 (7), 509-511, 2022.
7. **Topological data analysis of collective and individual epithelial cells using persistent homology of loops**, Bhaskar, D., Zhang, W., & Wong, I. *Soft Matter* 17, 4653-4664, 2021.
6. **Analyzing collective motion with machine learning and topology**, Bhaskar, D., Manhart, A., Milzman, J., Nardini, J., Storey, K., Topaz, C., & Ziegelmeier, L. *Chaos* 29, 123125, 2019.
5. **Motility-limited aggregation of mammary epithelial cells into fractal-like clusters**, Leggett, S., Neronha, Z., Bhaskar, D., Sim, J., Perdikari, T., & Wong, I. *PNAS* 116 (35), 17298-17306, 2019.
4. **Breast cancer cells transition from mesenchymal to amoeboid migration in tunable 3D silk-collagen hydrogels**, Khoo, A., Valentin, T., Leggett, S., Bhaskar, D., Bye, E., Benmelech, S., Ip, B., & Wong, I. *ACS Biomaterials Science & Engineering* 5 (9), 4341-4354, 2019.
3. **3D printed self-adhesive PEGDA-PAA hydrogels as modular components for soft actuators and microfluidics**, Valentin, T., DuBois, E., Machnicki, C., Bhaskar, D., Cui, F., Wong, I. *Polymer Chemistry* 10 (16), 2015-2028, 2019.
2. **Coupling mechanical tension and GTPase signaling to generate cell and tissue dynamics**, Zmurchock, C., Bhaskar, D., & Edelstein-Keshet, L. *Physical Biology*, 15 (4), 046004, 2018.
1. **Polarization and migration in the zebrafish posterior lateral line system**, Knútsdóttir, H., Zmurchok, C., Bhaskar, D., Palsson, E., Dalle Nogare, D., Chitnis, A. B., & Edelstein-Keshet, L. *PLoS Computational Biology*, 13 (4), e1005451, 2017.

⋆ co-first authors, † cover, ‡ co-senior authors

PREPRINTS

P6 **Dissecting glial scar formation by spatial point pattern and topological data analysis**, Manrique-Castano, D., Bhaskar, D., & ElAli, A. *bioRxiv*:10.1101/2023.10.04.560910 (submitted to *Nature Communications*)

P5 **Graph Topological Property Recovery with Heat and Wave Dynamics-based Features on Graphs**, Bhaskar, D., Zhang, Y., Xu, C., Sun, X., Fasina, O., Wolf, G., Nickel, M., Perlmutter, M., & Krishnaswamy, S. *arXiv:2309.09924* (submitted to *ICASSP 2024*)

Preprints *(Cont'd)*

P4 **Inferring dynamic regulatory interaction graphs from time series data with perturbations**, Bhaskar, D., Magruder, S., De Brouwer, E., Venkat, A., Wenkel, F., Wolf, G., & Krishnaswamy, S. *arXiv:2306.07803* (submitted to *LoG 2023*)

P3 **Capturing spatiotemporal signaling patterns in cellular data with geometric scattering trajectory homology**, Bhaskar, D., Moore, J., Gao, F., Rieck, B., Khasawneh, F., Munch, E., Greco, V., & Krishnaswamy S. *bioRxiv*:10.1101/2023.03.22.533807

P2 **Learnable filters for geometric scattering modules**, Tong, A., Wenkel, F., Bhaskar, D., Macdonald, K., Grady, J., Perlmutter, M., Krishnaswamy, S., & Wolf, G. *arXiv:2208.07458* (submitted to *IEEE Transactions on Signal Processing*)

P1 **A methodology for morphological feature extraction and unsupervised cell classification**, Bhaskar, D., Lee, D., Knútsdóttir, H., Tan, C., Zhang, M., Dean, P., Roskelley, C., & Edelstein-Keshet L. *bioRxiv*:10.1101/623793

Draft Manuscripts

D4 **Bridging sequence and structure: A joint embedding framework for predicting viral evolution and immune escape**, Schweinfurth, L., Bhaskar, D., Castro, E., Mostefai, F., Scicluna, M., Ni, S., Wolf, G., Hussin, J., Iwasaki, A. & Krishnaswamy S.

D3 **A probabilistic method for sampling α-shapes**, Winn-Nuñez, E., Witt, H., Bhaskar, D., Huang, R., Wong, I., Reichner, J., & Crawford, L.

D2 **Principles of ontogenetic allometry in the *C. elegans* nerve ring**, Emerson, S., Bhaskar, D., Moyle, M., Koonce, N., Morales, PA., Sager, G., Vásquez-Martínez, N., Clark, D., Mohler, W., Krishnaswamy S. & Colón-Ramos, D.

D1 **Topological data analysis using persistence images for comparing agent-based models of zebrafish patterning**, Bhaskar, D., Zhang, W., Seidel, E., Volkening, A., Sandstede, B., & Wong I.

Invited Talks

AMS Special Session on Applied Topology: Theory, Algorithms, and Applications, Joint Mathematics Meetings (JMM), Seattle, WA	**Jan 2024**
Dioscuri Centre in Topological Data Analysis, Polish Academy of Sciences *[Online]*	**Dec 2023**
Systems Medicine Seminar, University of Florida *[Online]*	**Nov 2023**
Computational Health Center Seminar, Helmholtz Munich, Germany	**Sep 2023**
Minisymposium on "Data-driven, Modeling and Topological Techniques in Cell and Developmental Biology", SMB Annual Meeting, Ohio State University	**Jul 2023**
Learning Learning Seminar, UMass Amherst	**May 2023**
AMS Special Session on Modeling Collective Behavior in Biology, Joint Mathematics Meetings (JMM), Boston, MA	**Jan 2023**
Pint of Postdoc, Yale Postdoc Association, New Haven, CT	**Apr 2022**
Applied Topology Seminar, AATRN *[Online]*	**Mar 2022**
Joint UBC and U. Utah MathBio Seminar *[Online]*	**Sep 2021**
Topological Data Analysis Seminar, Michigan State University *[Online]*	**Aug 2021**
Minisymposium on "Data-driven modeling across scales - from cytoskeleton to bacterial swarms to multicellular motility to angiogenesis", SMB Annual Meeting *[Online]*	**Jun 2021**
Applied Topology Seminar, Mathematical Institute, University of Oxford	**May 2021**
Thinking Out Loud, Samuel M. Nabrit Black Graduate Student Association, Brown University	**Nov 2019**
BIRS Workshop on Bridging Cellular and Tissue Dynamics from Normal Development to Cancer: Mathematical, Computational, and Experimental Approaches, Banff, AB	**Jun 2019**

Contributed Talks

Biomedical Engineering Society (BMES) Annual Meeting, Seattle, WA **Oct 2023**

2nd Symposium on Applications of Mathematical Sciences (MathSEE), Karlsruhe Institute of Technology **Sep 2023**

3rd Graduate Student Conference: Geometry and Topology meet Data Analysis and Machine Learning (GTDAML), Northeastern University **Jun 2023**

42nd Department of Genetics Annual Retreat, Yale School of Medicine, Westbrook, CT **Aug 2022**

The 39th Annual (Online) Workshop in Geometric Topology *[Online]* **Jun 2022**

AMS Contributed Paper Session on Algebraic Topology and Knot Theory, Joint Mathematics Meetings (JMM), Seattle, WA *[Online]* **Jan 2022**

2nd Workshop on Topological Methods in Data Analysis, Heidelberg University *[Online]* **Oct 2021**

83rd New England Complex Fluids Meeting, UMass Amherst **Jun 2020**

Continua Research Society Colloquium, Brown University **Apr 2019**

10th Annual q-bio Conference, Vanderbilt University **Jul 2016**

Canadian Undergraduate Mathematics Conference, Carleton University **Jul 2014**

Canadian Undergraduate Mathematics Conference, Université de Montréal **Jul 2013**

Teaching

Guest Lectures:

MATH 322a - Geometric and Topological Methods in Machine Learning — Yale, Fall '22
CEMA 0919 - An Introduction to Applied Mathematics — Summer@Brown '19

Graduate/Undergraduate Teaching Assistant:

DATA 1010 - Probability, Statistics & Machine Learning — Brown University, Fall '19
ENGN 2912B - Scientific Programming in C++ — Brown University, Fall '18
CPSC 313 - Computer Hardware & Operating Systems — UBC, Summer '16 & '17
MATH 257/316 - Partial Differential Equations — UBC, Fall '16
MATH 256 - Differential Equations — UBC, Spring '16
MATH 253 - Multivariable Calculus — UBC, Fall '15
MATH 307 - Applied Linear Algebra — UBC, Fall '15
CPSC 259 - Data Structures & Algorithms for Electrical Engineers — UBC, Spring '13 & '14
CPSC 260 - Data Structures & Algorithms for Computer Engineers — UBC, Fall '12
CPSC 260 - Object-Oriented Program Design (old syllabus) — UBC, Summer '11
CPSC 101 - Connecting with Computer Science — UBC, Spring '11, Summer '11
CPSC 211 - Introduction to Software Development (old syllabus) — UBC, Fall '10

Pedagogical Training:

Inclusive Leadership Training, Yale Office of Diversity and Inclusion — 2023
Teaching Consultant Program, Brown Sheridan Center — 2020
Course Design Seminar, Brown Sheridan Center — 2020
Reflective Teaching Seminar, Brown Sheridan Center — 2019
Instructional Skills Workshop, UBC Center for Teaching, Learning and Technology — 2016

Mentorship

Yale College First-Year Summer Research Fellowship in the Sciences & Engineering

Topic: Adversarial Knowledge Graph Embedding for Indication Expansion **Summer 2022**
Student: Garrek Chan (Saybrook College, Class of 2025)

MENTORSHIP *(Cont'd)*

Summer Undergraduate Math Research at Yale (SUMRY)

Topic: Directed-graph based Inference in Machine Learning **Summer 2022**
Students: Tesfa Asmara, Kincaid MacDonald, Nhi Nguyen, Guy Thampakkul & Joia Zhang

Topic: Diffusion Geometry and Topology **Summer 2021**
Students: Kincaid MacDonald, Jennifer Paige, Dawson Thomas & Sarah Zhao

Independent Study Projects

Topic: Identifying Transitions in Collective Cell Behavior using TDA **Spring 2020**
Student: William Zhang (Brown University, Sc.B.'22)

Topic: Diffusion Geometry and Topology **Fall 2020**
Student: William Zhang (Brown University, Sc.B.'22)

BrownConnect Collaborative SPRINT Award

Topic: Data-driven Modeling of Collective Motion on Curved Surfaces in 3D **Summer 2020**
Student: Tej Stead (Brown University, Sc.B.'23)

Brown University Undergraduate Teaching and Research Award

Topic: Computational Models of Swarming and Collective Cell Motility **Spring 2019**
Student: Subhanik Purkayasta (Brown University, Sc.B.'21)

Undergraduate Honors Thesis

Topic: Profiling EMT in 3D Microenvironments using TDA **Fall 2018, Spring 2019**
Student: Zachary J. Neronha (Brown University, Sc.B.'19)

NSERC Undergraduate Summer Research Award

Topic: Cell Cluster Analysis and Neighbour Detection **Summer 2017**
Student: Cindy Tan (UBC, B.Sc.'19)

Topic: Simulating Cell-Cell Interactions & Migration in Multicellular Tissues **Summer 2017**
Student: MoHan Zhang (UBC, B.Sc.'18)

Topic: Morphology-Based Cell Classification **Summer 2016**
Student: Darrick Lee (UBC, B.A.Sc.'16)

Topic: Extending the CHASTE Open Source C++ Simulation Library **Summer 2015**
Student: Eviatar Bach (UBC, B.Sc.'17)

POSTER PRESENTATIONS

Biomedical Engineering Society (BMES) Annual Meeting, Seattle, WA **Oct 2023**

6th Montreal AI and Neuroscience (MAIN) Conference, Montreal, QC **Dec 2022**

17th Machine Learning in Computational Biology (MLCB) Conference *[Online]* **Nov 2022**

Conference on the Mathematical Theory of Deep Neural Networks (DeepMath), UC San Diego **Nov 2022**

Biomedical Engineering Society (BMES) Annual Meeting, San Antonio, TX **Oct 2022**

21st European Conference on Computational Biology (ECCB), Sitges, Spain **Sep 2022**

Bridging Applied and Quantitative Topology Workshop, AATRN *[Online]* **May 2022**

Workshop on Geometrical and Topological Representation Learning, ICLR *[Online]* **Apr 2022**

Poster Presentations *(Cont'd)*

Learning Meaningful Representations of Life (LMRL) Workshop, NeurIPS *[Online]*	**Dec 2021**
ELLIS Machine Learning for Molecule Discovery Workshop, NeurIPS *[Online]*	**Dec 2021**
Applied Algebraic Topology Research Network (AATRN) Poster Session *[Online]*	**Oct 2021**
American Society for Reproductive Medicine Scientific Congress & Expo *[Online]*	**Oct 2020**
Society for Mathematical Biology Annual Meeting† *[Online]*	**Aug 2020**
New England Computer Vision Conference, Brown University	**Dec 2019**
Biomedical Engineering Society (BMES) Annual Meeting, Philadelphia, PA	**Oct 2019**
Frontiers in Biophysics Conference, UBC	**Jun 2017**
Frontiers in Biophysics Conference, SFU	**Jun 2016**
Multidisciplinary Undergraduate Research Conference, UBC	**Mar 2015**
Frontiers in Biophysics Conference, UBC	**Mar 2015**
Mathematics at the Frontier of Developmental Biology Workshop, PIMS/UBC	**Jul 2014**

† Best Mathematical Oncology Poster Award

Service and Leadership

Co-Organizer:

7th Annual Yale Postdoc Symposium, Yale University, New Haven, CT	**May 2024**
AMS Special Session on "Geometry and Topology of High-Dimensional Biomedical Data", Joint Math Meetings, San Francisco, CA	**Jan 3-6, 2024**
6th Annual Yale Postdoc Symposium, Yale University, New Haven, CT	**May 25, 2023**
Minisymposium on "The Convergence of Data, Geometry, and Biology: Insights from the 'shape' of Biological Data", Sigma Xi International Forum for Research Excellence (IFoRE), Alexandria, VA	**Nov 3-6, 2022**

Reviewer:

Journals:	Nature Communications Materials, Cell Systems, PLOS Computational Biology, npj Systems Biology and Applications, Bulletin of Mathematical Biology
Conferences:	RSGDREAM 2022 (RECOMB/ISCB), SampTA 2023, NeurIPS 2023, MLCB 2023, ICLR 2024
Workshops:	LMRL Workshop 2022 (NeurIPS)

Membership:

Golden Key International Honour Society	**2010 — Present**
Society for Mathematical Biology (SMB)	**2017 — Present**
Sigma Xi, The Scientific Research Honor Society	**2018 — Present**
American Mathematical Society (AMS)	**2019 — Present**
Biomedical Engineering Society (BMES)	**2019 — Present**
Institute of Electrical and Electronics Engineers (IEEE)	**2022 — Present**
Society for Industrial and Applied Mathematics (SIAM)	**2023 — Present**

References

Available upon request.