DHANANJAY BHASKAR

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Research Interests Representation Learning, Graph ML, Geometric Deep Learning, Dynamical Systems, Agent-Based Models, Topological Data Analysis, Mathematical & Computational Biology

Appointments

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

Postdoctoral Research Associate
Yale - Boehringer Ingelheim Biomedical Data Science Fellow
Co-coordinator, Yale Postdoc Association Symposium Committee
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

17. **A flowartist for high-dimensional cellular data**, Macdonald, K.*, Bhaskar, D.*, Thampakkul, G., Nguyen, N., Zhang, J., Perlmutter, M., Adelstein, I., & Krishnaswamy S. (to appear in *IEEE MLSP 2023*)

16. **Wire before you walk**, Asmara, T., Bhaskar, D., Adelstein, I., Krishnaswamy, S., & Perlmutter, M. (to appear in *Asilomar Conference on Signals, Systems, and Computers, 2023*)

PUBLICATIONS *(Cont'd)*

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.
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. *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

P7 **A probabilistic method for sampling α-shapes**, Winn-Nuñez, E., Witt, H., Bhaskar, D., Huang, R., Wong, I., Reichner, J., & Crawford, L.

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

Preprints *(Contd.)*

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*)

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*, DOI: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*, DOI:10.1101/623793

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**

Contributed Talks *(Cont'd)*

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**

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**
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**

† Winner of the best poster award in the Mathematical Oncology subgroup

Teaching Experience

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

TEACHING EXPERIENCE *(Cont'd)*

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)

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 **Sep 2018 - May 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)

Mentorship *(Cont'd)*

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)

Service and Leadership

Co-Organizer:

AMS Special Session on "Geometry and Topology of High-Dimensional Biomedical Data", Joint Math Meetings, San Francisco, CA **Jan 3-6, 2024**

6^{th} 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:

Professional: SMB (since 2017), AMS (since 2019), BMES (since 2019), IEEE (since 2022), SIAM (since 2023)

Honor Societies: Sigma Xi, Golden Key International Honour Society

Workshops and Training

ICERM Workshop on Topology and Geometry in Neuroscience **Oct 16 - 20, 2023**

Virtual Hands-on Workshop on Computational Biophysics, National Center for Multiscale Modeling of Biological Systems (MMBioS) *[Online]*] **Jul 5 - 8, 2022**

ICERM Workshop on Geometric and Topological Methods in Data Science **Dec 16 - 17, 2021**

OxML.2020 Machine Learning Summer School†, Oxford University *[Online]* **Aug 17 - 25, 2020**

Petascale Computing Institute *[Online]* **Aug 19 - 23, 2019**

AMS Mathematic Research Communities Program on Modeling in Biological and Social Systems, West Greenwich, RI **Jun 17 - 23, 2018**

Research Computing Summer School, UBC **Jun 19 - 22, 2017**

Tenth q-bio Summer School on Membrane Dynamics, University of New Mexico **Jul 11 - 22, 2016**

EMBO Course on Multi-level Modelling of Morphogenesis, John Innes Centre, Norwich, UK **Jul 12 - 24, 2015**

Joint CAMBAM-MBI-NIMBioS Summer School on Nonlinear Dynamics in Biological Systems, McGill University **Jun 1 - 12, 2015**

† Among top 12% applicants accepted into the program