Sushovan Majhi

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RESEARCH INTERESTS

Applied Topology, **Topological Data Analysis (TDA)**, **Computational Geometry**, **Pattern and Shape Matching**, and **Statistical Finance**.

My research primarily revolves around the interface of mathematics, computer science, and the foundation of data science. More specifically, I am motivated to develop provable inference techniques for data science that are inspired by topology and geometry. I also keep a keen interest in applying TDA to fascinating, applied problems arising in domains, like biology, medicine, genetics, finance, and dynamical systems.

TEACHING INTERESTS

Mathematics: Algebraic Topology, Computational Topology, Differential Geometry, Manifold Theory, Analysis, Linear Algebra, Calculus
Data Science: Probability Theory, Mathematical Statistics, Regression Analysis, Topological Data Analysis, Machine Learning, Data Mining, Algorithm Design for Data Science
Computer Science: Algorithms and Data Structures, Computational Geometry, Complexity Theory

WORK EXPERIENCE

- **Visiting Assistant Professor** — **August 2023–*current***
  Data Science Program, George Washington University, D.C., USA
  Role: Teaching data science and computer science courses to graduate students in the [Data Science Program](#).

- **Postdoctoral Research Fellow** — **January 2021–July 2023**
  School of Information, University of California, Berkeley, USA
  Role: The responsibilities include conducting research broadly in data science, forging new research collaborations, organizing research webinar series.

- **Data Science Instructor** — **January 2021–July 2023**
  School of Information, University of California, Berkeley, USA
  Role: According to Fortune[1], [MIDS](#) is the No.2-ranked Master of Information and Data Science program in the US. Alongside instructing *Statistics for Data Science* for the program, I develop course materials, devise and maintain technology to facilitate teaching and learning.

- **Lecturer (MIDS Program)** — **August 2020–December 2020**
  School of Information, University of California, Berkeley, USA
  Role: The position offered me (off-campus) work experience during my doctoral studies, and has served as a Curricular Practical Training (CPT).

EDUCATION

- **Doctor of Philosophy** in **Mathematics** — **August 2014–December 2020**
  Tulane University, New Orleans, LA, USA.
  Advisor: **Prof. Carola Wenk**
  Courses: computational geometry, computational topology, topological data analysis, differential geometry, differentiable manifolds, algorithms, data structures, computational complexity, applied mathematics, scientific computing.

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[1] https://fortune.com/education/information-technology/masters/rankings/best-online-masters-in-data-science

- **Master of Science** in **Mathematics**   **August 2009–May 2012**
  Tata Institute of Fundamental Research, Bangalore, India
  Courses: ordinary and partial differential equations, probability theory, complex analysis, functional analysis, numerical linear algebra, measure theory, mechanics.

- **Bachelor of Science** in **Mathematics** (Hons.)   **July 2006–May 2009**
  Ramakrishna Mission Vidyamandira, **Calcutta University**, West Bengal, India
  Courses: calculus, real analysis, linear algebra, numerical analysis, game theory, statistics, physics.

JOURNAL PAPERS AND PREPRINTS

6. **Sushovan Majhi**. Demystifying Latschev's theorem: Manifold Reconstruction from noisy data, 20 pages, June 2023. Available at: `arXiv:2305.17288[math.AT]`
   • Submitted to *Discrete and Computational Geometry*

5. **Sushovan Majhi**. Vietoris–Rips complexes of metric spaces near a metric graph. *Journal of Applied and Computational Topology*, May 2023 DOI: `10.1007/s41468-023-00122-z`
   Also available at: `arXiv:2204.14234[math.AT]`

4. **Sushovan Majhi**, Jeffrey Vitter, and Carola Wenk. Approximating Gromov-Hausdorff distance in Euclidean space. *Computational Geometry: Theory and Applications*, 116:102034, 2024.
   DOI: `10.1016/j.comgeo.2023.102034`

3. **Sushovan Majhi** and Carola Wenk. Distance Measures for geometric graphs, 16 pages. Also available at: `arXiv:2209.12869[cs.CG]`
   • To appear *Computational Geometry: Theory and Applications*

2. Anish Rai, Ajit Mahata, Md Nurujjaman, **Sushovan Majhi**, and Kanish Debnath. A sentiment-based model-ing and analysis of stock price during the COVID-19: U- and Swoosh-shaped recovery. *Physica A: Statistical Mechanics and its Applications*, 592:126810, 2022. DOI: `10.1016/j.physa.2021.126810`

1. Brittany Terese Fasy, Rafal Komendarczyk, **Sushovan Majhi**, and Carola Wenk. On the reconstruction of geodesic subspaces of $\mathbb{R}^N$. *International Journal of Computational Geometry & Applications*, 32(1):91–117, 2022. DOI: `10.1142/S0218195922500066`

PEER-REVIEWED CONFERENCE PAPERS

2. Erin Chambers, Brittany Fasy, Benjamin Holmgren[*], **Sushovan Majhi**, and Carola Wenk. Metric and path-connectedness properties of the Frĕchet distance for paths and graphs. In Proceedings of the *34th Canadian Conference on Computational Geometry*, CCCG 2022, Concordia University, Montreal, QC, Canada. Available at: `arXiv:2308.00900[cs.CG]`

1. **Sushovan Majhi**. Graph mover's distance: An efficiently computable distance measure for geometric graphs. In Proceedings of the *34th Canadian Conference on Computational Geometry*, CCCG 2023, Concordia University, Montreal, QC, Canada. Available at: `arXiv:2306.02133[cs.CG]`

WORKSHOP CONTRIBUTIONS

`Link` Sushovan Majhi and Carola Wenk. Distance Measures for Geometric Graphs. *arXiv:2209.12869 [cs.CG]*, 2022 Brittany Terese Fasy, Sushovan Majhi, and Carola Wenk. Threshold-based graph reconstruction using discrete Morse theory. In *Fall Workshop on Computational Geometry*, New York, NY, November 2018

`Link` Brittany Terese Fasy, Sushovan Majhi, and Carola Wenk. Threshold-based graph reconstruction using discrete Morse theory. In *Fall Workshop on Computational Geometry*, New York, NY, November 2018

`Link` Brittany Terese Fasy, Rafal Komendaczyk, Sushovan Majhi, and Carola Wenk. Topological reconstruction of metric graphs in $\mathbb{R}^n$. In *Fall Workshop on Computational Geometry*, New York, NY, October 2017

Research Experience

- **Topological and Statistical Methods in Predicting the Crash and Recovery of Stock Markets** **March 2021–*current***
  Collaborator: Md. Nurujjaman, NIT Sikkim, India
  In the aftermath of stock market crash due to COVID-19, not all sectors recovered in the same way. We proposed novel models to capture the different types of recovery profiles for Indian stocks. We also employed the **Empirical Mode Decomposition** (EMD) for a statistical significance analysis of our model.

  We currently look into the possibility of predicting a future crash in a financial sector—using tools from **Topological Data Analysis** (TDA).

- **Topological and Geometric Signature-Based Shape Comparison** **October 2021–*current***
  Collaborators: Erin Chambers, Liz Munch, and Carola Wenk
  We consider geometric and topological signatures to concisely represent large datasets to facilitate their easy description and efficient comparison. To this end, we look for signatures in the class of algebraic, geometric, and graphical signatures. We have proposed new similarity measures for geometric graphs, and studied their computational aspects.

- **Computation of Gromov-Hausdorff Distance in Euclidean Space** **April 2019–December 2020**
  Collaborators: Helmut Alt, Jeffrey Vitter, and Carola Wenk
  We investigate the computational aspects of Gromov-Hausdorff distance between sets equipped with the Euclidean metric. We used the Hausdorff distance under isometry to develop an approximation algorithm for Gromov-Hausdorff distance on the real line with a tight approximation factor of $\left(1 + \frac{1}{4}\right)$.

- **Topological Reconstruction of Geodesic Spaces** **December 2016–May 2019**
  Collaborators: Brittany Fasy and Rafal Komendarczyk
  Role: Research Assistant
  PI: Carola Wenk (NSF CCF-161846)
  We investigate the reconstruction of geodesic subspaces of Euclidean spaces using the Vietoris-Rips and Čech complexes from a dense sample around it. We propose two new sampling parameters: **distortion** of embedding and **convexity radius** of the underlying geodesic space. We guarantee a successful computation of the Betti numbers. For the special case of planar graphs, we also develop an algorithm for its geometric reconstruction.

- **Dynamics and Prognosis of Chronic Myelogenous Leukemia (CML)** **August 2012–November 2013**
  National Center for Biological Sciences, TIFR, Bangalore, India
  Role: Junior Research Fellow
  PI: Seema Nanda
  In this joint effort to develop better prognostic tools for doctors, computational scientists teamed up with medical officers and biologists to understand the dynamics of CML by modeling the disease by systems of **differential equations**. In our parameter fitting, we made use of the big existing data collected from a large pool of CML patients. We also performed (statistical) **sensitivity analysis** to better understand the parameter spaces for our model.

Teaching Experience

- **Statistics for Data Science, MIDS** **August 2020–*current***
  School of Information, University of California, Berkeley, USA
  The course covers the following topics: probability theory, sampling distributions, estimators and convergence theorems, confidence intervals, hypothesis testing, and regression.

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* Undergraduate student at the time of research or submission

- **Undergraduate Statistics for Business Students** **Summer 2019**
  Tulane University, USA
  The course covered the following topics: sampling methods, probability theory, random variables, sampling distribution, confidence intervals, hypothesis testing, and linear regression.

- **Linear Algebra, Complex Analysis** **January 2013–June 2013**
  Christ University and Scimetric Pvt Ltd, Bangalore, India

- **Analysis, Linear Algebra, Complex Analysis** **November 2011–July 2012**
  GATE-IIT Coaching Institute, JP Nagar, Bangalore, India
  Graduate level, for competitive national exams, e.g., National Eligibility Test

- **Analysis and Linear Algebra** **February 2012–July 2012**
  MES College, Department of Mathematics, Malleswaram, Bangalore, India

ACADEMIC SERVICES

- I have been a reviewer for the Journal of Combinatorial Optimization.

- I have been a reviewer for conferences, like International Symposium on Computational Geometry, International Symposium on Spatial and Temporal Databases, European Workshop on Computational Geometry, ACM International Conference on Advances in Geographic Information Systems, WADS Algorithms and Data Structures Symposium.

- I organized SIAM Graduate Student Chapters at Tulane University.

- I have been organizing data science webinar series at the University of California, Berkeley.

COMPUTATIONAL SKILLS

Java, C, R, Python, Ruby, JavaScript, SQL, Bash.

SOFTWARE PROJECTS

- **Simplicial Complexes in JS** GitHub
  JavaScript implementation of some of the widely used computations on simplicial complexes. The library also implements the Smith Normal Form in order to compute the homology groups of an abstract complex.

- **Shape Reconstruction Visualization** WebApp | GitHub
  To complement my PhD research, I implemented my topological reconstruction algorithm for planar metric graphs in this library. The library is written in JavaScript and made available to users as a web-app.
  Skills: JavaScript, HTML, CSS.

ENTREPRENEURIAL EXPERIENCE

- **Scimetric Edulabs Private Limited** **December 2012–April 2017**
  Bangalore, India
  Role: **co-founder** and **director**
  In this start-up venture, our objective was to motivate and train students in higher education. We won franchise to work with several private colleges in India. We coached science students for standardized entrance tests for PhD and academic jobs. The company employed 6 trainers.

AWARDS, SCHOLARSHIPS, RECOGNITION

- **Travel Grant**, University of California, Berkeley

- **UGC-CSIR NET Research Fellowship**, India, June 2012

- **TIFR Junior Research Fellowship** for pursuing Integrated PhD studies at TIFR-CAM, Bangalore, India. August 2009.

- **Secured grade "A" in SCIENCE TALENT SEARCH EXAMINATION**
  conducted by JATIYA VIJNAN PARISAD and INDIAN SCIENCE CONGRESS ASSOCIATION

INVITED TALKS AND ACCEPTED ABSTRACTS

- **The 30th Fall Workshop on Computational Geometry**   October 14–15, 2022
  North Carolina State University, USA

- **Title:** Topological Methods in the Reconstruction and Comparison of Shapes   February, 2022
  Mathematics Department, ICFAI University, Tripura, India

- **Title:** A Taste of Topological Data Analysis (TDA): Reconstruction of Shapes   September, 2021
  Department of Mathematics, Hunter College, NY, USA

- **Fall Workshop on Computational Geometry**   October, 2018
  Queens College, New York, USA

- **Fall Workshop on Computational Geometry**   November, 2017
  SUNY (Stony Brook), New York, USA

HOBBY

In my spare time, I write tutorials on *random* topics in order to make mathematics and statistics a little more interactive; they can be found here: https://www.smajhi.com/tutorials. I also enjoy playing the piano and classical guitar.