

Sushovan Majhi

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RESEARCH INTERESTS

Topological data analysis (TDA), applied algebraic topology, computational topology, computational geometry, road-map reconstruction from GPS trajectory data.

My research primarily focuses on **shape reconstruction** and **big data analysis**. More specifically, I am interested in solving real-world problems using tools from **algebraic topology** and **geometry**. In order to analyze large, complex, and noisy data, I develop provable and efficient techniques to find and classify significant geometric and topological features.

TEACHING INTERESTS

- **UNDERGRADUATE:** Calculus, statistics, probability theory, real analysis, topology, linear algebra, differential geometry, algorithms, computational geometry, data science.
- **GRADUATE:** Analysis, algebraic topology, manifold theory, algorithms, computational complexity, computational geometry.

EDUCATION

- **Doctor of Philosophy in Mathematics** August 2014–May 2020 (expected)
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.
- **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, and statistics.

RESEARCH EXPERIENCE

- **Computation of Gromov-Hausdorff Distance in Euclidean Space** April 2019–current
Collaborators: [Carola Wenk](#), [Jeffrey Vitter](#), and [Helmut Alt](#)
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 $(1 + \frac{1}{4})$.
- **Discrete Morse Theory in Graph Reconstruction** October 2018–current
Collaborators: [Carola Wenk](#) and [Brittany Terese Fasy](#)
We propose a threshold-based framework to obtain both topologically and geometrically faithful reconstruction of planar metric graphs from (noisy) spatial data. We make use of topological ideas, like discrete Morse theory and persistence homology and statistical ideas like kernel density estimation (KDE) to capture statistically significant features.
- **Topological Reconstruction of Geodesic Spaces** December 2016–May 2019
Collaborator: [Carola Wenk](#), [Rafal Komendarczyk](#), [Brittany Fasy](#)
Role: Research Assistant
PI: Carola Wenk

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 a planar metric 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, mathematicians 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.

PUBLICATIONS

[Link](#) Sushovan Majhi, Jeffrey Vitter, and Carola Wenk. Approximating Gromov-Hausdorff Distance in Euclidean Space. *arXiv:1912.13008 [math.MG]*, 2019

[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 Komendarczyk, Sushovan Majhi, and Carola Wenk. On the Reconstruction of Geodesic Subspaces of \mathbb{R}^n . *arXiv:1810.10144 [math.AT]*, 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

TEACHING EXPERIENCE

- **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

COMPUTATIONAL SKILLS

PROGRAMMING LANGUAGES: Java, C, Python, Ruby, JavaScript, SQL, Matlab, Bash.

OTHERS: Databases, Git, Ruby on Rails, REST, AWS, Heroku, Jekyll.

SOFTWARE PROJECTS

- **Shape Reconstruction Visualization** [Link](#) | [Github](#)
To complement my 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.
- **Avimukh** [Link](#)
Avimukh is a Bengali website for poets, writers, and bloggers. I designed its backend in Ruby on Rails framework. The web-app is hosted on Heroku.
Skills: Ruby on Rails, Ruby, SQL, JavaScript, HTML.

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.

SCHOLARSHIPS AND CERTIFICATES

- **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

CONFERENCES AND WORKSHOPS ATTENDED

- **NSF-CBMS Conference and Software Day on Topological Methods in Machine Learning and Artificial Intelligence** May 13–18, 2019
Department of Mathematics, College of Charleston, South Carolina, 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
- **Spring School on Discrete and Computational Geometry** April 17–21, 2017
Simon’s Center, Stony Brook, New York, USA
- **Topology, Geometry, and Data Analysis Conference at OSU** May 16–20, 2016
Ohio State University, Columbus, USA