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, data science, real analysis, topology, linear algebra, differential geometry, algorithms and data structures, computational geometry.
- **Graduate:** Analysis, algebraic topology, manifold theory, algorithms, computational complexity, computational geometry.

Work Experience

- **Postdoctoral Research Fellow in Data Science** **January 2021–*current***
  School of Information, University of California, Berkeley, USA

- **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.

- **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: 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 $\left(1+\frac{1}{4}\right)$.

- **Discrete Morse Theory in Graph Reconstruction** **October 2018–*current***
  Collaborators: Brittany Fasy and Carola Wenk
  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: Brittany Fasy and Rafal Komendarczyk
  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, 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.

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, Submitted to *JoCG (Journal of Computational Geometry)*

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

- **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.

- **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