Sunia Tanweer

Third Year Dual PhD Candidate

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Executive Summary

PhD candidate in Computational Mathematics and Mechanical Engineering with expertise in researching and developing data science algorithms for real-world applications. Skilled in Python programming, topological data analysis, dynamical systems and statistical modeling. Adept at integrating machine learning algorithms into production systems, with a strong focus on performance optimization and documentation.

Education

Michigan State University *East Lansing, MI, USA*

Dual PhD in Mechanical Engineering, and Computational Mathematics, Sciences and Engineering *Sept 2022 - May 2026*

- CGPA: 4.0/4.0 | Advisor(s): Dr Firas A. Khasawneh & Dr Elizabeth Munch
- Thesis: Analyzing Dynamical Systems and Directed Graphs with Topological Data Analysis, Stochastic Theory and Machine Learning.
- Experienced in data science, topological data analysis, time series forecasting, stochastic dynamics and modelling techniques, Monte Carlo Markov chains, machine learning, deep learning, probability and statistics, algorithm development and translation to code.
- Main courses: Numerical Methods of Differential Equations, Numerical Linear Algebra, Mathematical Foundations of Data Science, Stochastic Processes, Analysis of Stochastic Processes, Nonlinear Dynamics, Parallel Computing, Scientific Machine Learning, Computational Statistics, Deep Learning, Data Structures

National University of Sciences and Technology (NUST) *Islamabad, Pakistan*

Bachelors in Mechanical Engineering *Sept 2017 - May 2021*

- CGPA: 3.95/4.00 – Summa Cum Laude (awarded President's Gold Medal for Academic Excellence)
- US State Department's fully funded merit-based Global UGRAD Semester Exchange Scholarship for 6th semester at University of Wyoming (Laramie, WY, USA)—worth over *$25000*. Selected out of 14000+ applicants from all over Pakistan. Mentioned in President's Honor Roll.

Research and Work Experience

Michigan State University *East Lansing, MI, USA*

Research and Teaching Assistant *Sep 2022 - Ongoing*

- Solved a longstanding 50-year-old problem in stochastic dynamics by introducing novel algorithms for detecting bifurcations in stochastic time series from density estimates using topological data analysis, Bayesian spatial modelling, and statistical methods.
- Exploring topology of directed graphs derived from climate models using asymmetric filtrations to explore weather regimes.
- Developed data pipelines and fine-tuned machine learning classifiers like SVM, Logistic Regression, and Random Forests to predict epileptic seizures with topological machine learning, achieving over 99% accuracy for single-channel data. Exploring data fusion techniques to enhance performance with multi-channel classification beyond the current 75% accuracy.
- Modelling epidemics using stochastic compartmental models to compare effects of white, Ornstein-Uhlenbeck and lognormal noise, and provide data-driven predictions of disease spread through bifurcation parameter estimation.
- Taught *Computational Modeling and Data Analysis* to sophomores, guiding in Python, time series analysis and forecast, graph theory and machine learning (with emphasis on Pandas, Seaborn, and Statsmodels). Overall teaching performance rated 18% above average.
- Cleaned, packaged, and documented code into an open-source Python package, `teaspoon`, using Jupyter Notebook, GitHub and Sphinx with unit-tests.

Engro Fertilizers Limited *Daharki, Pakistan*

Graduate Engineer (Maintenance) *Oct 2021 - June 2022*

- Saved $5 million by preventing a forced outage of the plant for 5-6 production days, through leading an efficient implementation of a high-risk 1 ton hot box-up at a major leakage of Process Air (1000 degF, 550 psi pressure, 50 feet in air).
- Improved operational efficiency by 13% and increased profit by $0.2 million through procedures standardization and streamlined job assignments to my team of 20 technicians, resulting in decreased overtime worker costs.

Computations for Advanced Materials and Manufacturing Lab *University of Wyoming, WY, USA*

Undergraduate Research Assistant *February 2020 – December 2020*

- Developed and verified user defined material subroutines (uhyper and vumat) of Murnaghan model of hyperelasticity for ABAQUS.
- Wrote a structured mesh model for ABAQUS using MATLAB, and utilized bash and python scripting for results' extraction, to detect corrosion using third order elastic constants' effect on second harmonic generated by a Lamb wave as a Non-Destructive Testing technique.

Publications

- **Tanweer, S.** & Khasawneh, FA. (*2024*, May). Topological detection of phenomenological bifurcations with unreliable kernel densities. Probabilistic Engineering Mechanics. https://doi.org/10.1016/j.probengmech.2024.103634.
- **Tanweer, S.**, Khasawneh, FA., & Munch, E. (*2024*, March). Robust Zero-crossings Detection in Noisy Signals using Topological Signal Processing. Foundations of Data Science. https://doi.org/10.3934/fods.2024006.
- **Tanweer, S.**, Khasawneh, FA., Munch, E. et al. (*2024*, February). A topological framework for identifying phenomenological bifurcations in stochastic dynamical systems. Nonlinear Dyn. https://doi.org/10.1007/s11071-024-09289-1
- Zhao, C., **Tanweer, S.**, Li, J., Lin, M., Zhang, X., & Liu, Y. (*2021*, August). Nonlinear Guided Wave Tomography for Detection and Evaluation of Early-Life Material Degradation in Plates. Sensors, 21(16), 5498.
- Zhao, C., **Tanweer, S.**, Li, J., Lin, M., Zhang, X., & Liu, Y. (*2021*, July). Early Fatigue Damage Evaluation of Nonlinear Guided Wave Imaging in Hyperelastic Materials. In Quantitative Nondestructive Evaluation (Vol. 85529, p. V001T11A009). American Society of Mechanical Engineers.

Presentations

- "Dynamics-Aware Filtrations-II", Joint Mathematics Meetings (JMM), Seattle, WA, January 2025.
- "Homological Bifurcations in Probabilistic descriptions of dynamical systems", Joint Mathematics Meetings (JMM), Seattle, WA, January 2025.
- Invited one-hour talk: "A comprehensive guide to detecting phenomenological bifurcations in stochastic systems using TDA", TDA Seminar, MSU, East Lansing, April 2024.
- "Establishing a Topology-Driven Framework for Phenomenological Bifurcations in Stochastic Systems", Regional Mathematics and Statistics Conference (RMSC), Greensboro, NC, November 2023.
- "A Topological Approach to Quantify Phenomenological Bifurcations in Stochastic Dynamical Systems", SIAM Great Lakes Meeting, East Lansing, MI, October 2023.
- "Exploring Topological Data Analysis for Identifying Phenomenological Stochastic Bifurcations", SIAM Conference on Applications of Dynamical Systems (DS23). Portland, OR, May 2023.
- "Robust Zero-Crossing Detection with Persistent Homology", 2nd MSU CMSE Data Science Student Conference (DISC). Michigan State University, East Lansing, MI, December 2022.

Selected Semester Projects

- *Time Series Forecasting*: Implemented the Random Feature Map-based Kalman Filter algorithm for time series forecasting, achieving 5x speedup.
- *Data Science*: Time series prediction for Crowdstrike stock values using moving average, ARIMA, and Ornstein-Uhlenbeck modeling.
- *Data Management SQL*: Used PostgreSQL to filter out unicorn companies for investment by manipulating and inner joining multiple dataframes.
- *Numerical Differential Equations*: Comparative analysis of discretization level for a McCormack compressible shock tube solver.
- *Parallel Computing*: Parallelized Strauss Point Process modeling via Monte Carlo methods.
- *Machine Learning:* Built an e-commerce multiclass clothing classifier using CNN with PyTorch, achieving 89% accuracy.
- *Theory of Vibrations*: Validation of closed-form expressions for crossing rate in narrow-band processes.
- *Heat and Mass Transfer*: Simulated and compared one-dimensional steady-state heat transfer in multiple commonly used fin profiles using ABAQUS.
- *Control Systems*: Implemented an Octave script for Routh-Hurwitz Criterion of stability.

Skills

Programming	Python, C++, MATLAB / Octave, Fortran, R, SQL, AWS Cloud Computing, HPC SLURM, Parallel Computing (MPI, OpenMP)
Computer Aided Design	ProEngineer / Creo, Soliworks, AutoCAD, SpaceClaim/DesignModeler
Data Science	Statsmodels, PyMC3, scikit-learn, PyTorch, TensorFlow, Machine Learning, Deep Learning, Time Series Analysis Forecasting, Hypothesis Testing, Stochastic Modelling, Markov Chains
Software Development	Sphinx (documentation), Markdown (documentation), Git (version control), Unit Testing, LaTeX

Achievements

- Awarded AMS graduate student travel grant to present at JMM 2025—worth *$1400*.
- 1 of 30 participants for AMS' Mathematics Research Communities conference 2024—awarded funding worth *$2000* by NSF.
- Received the Graduate Leadership Fellowship (College of Engineering) worth *$3000* for 2024.
- Awarded *$700* travel and accommodation fund for presenting at RMSC by NSF.
- Awarded a laptop in Prime Minister's merit-based laptop scheme (Pakistan).
- Awarded NESCOM's undergraduate fellowship (Pakistan) of 2019 from the entire batch of 110 students.
- Nationwide first position in NUST entrance test 2017 out of 70000+ students achieving Chancellor's scholarship in 1st semester.
- Among the top 25 participants in National Round (Pakistan) of International Physics Olympiad (IPhO) 2017 (NPTC-21) out of 5000+ students.
- Merit scholarship by Federal Board Islamabad (FBISE) for 6th position in Pakistan (HSSC 2017).
- Special Mention in South Asia Model United Nation (SAMUN) 2017 for UN-Security Council.

Professional Activities

- One of the organizers of a minitutorial "Topological Signal Processing for Dynamical Systems" at SIAM Conference on Applications of Dynamical Systems (DS23). Portland, OR, May 2023.
- Regular contributor of open-source software to python package *teaspoon* for topological data analysis.
- Reviewer and Copy-Editor for Journal of Emerging Investigators (JEI).
- Member of Society of Industrial and Applied Mathematics (SIAM) and American Mathematics Society (AMS).
- Underwent Train-the-Trainer T4DS training (06-20-2023) on managing and training students in topological data analysis: 1 of the 9 funded participants.
- Trained in CIRTL Supporting Neurodivergent Students (11-08-2023) on forms of neurodiversity, problems faced by neurodiverse students and methods of supporting them.