

Sunia Tanweer

PHD APPLIED RESEARCH SCIENTIST (MACHINE LEARNING AND TIME SERIES)

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Executive Summary

PhD in computational mathematics with expertise in time series analysis, developing and deploying ML models, stochastic simulations, and data-driven algorithms for real-world applications. Skilled in Python and experienced in integrating machine/deep learning techniques into production.

Education

Michigan State University

East Lansing, MI, USA

Dual PhD in Mechanical Engineering, and Computational Mathematics

Sept 2022 - May 2026

- CGPA: 4.0/4.0 | Advisor: Dr Firas A. Khasawneh | Fitch Beach Award for Outstanding Research
- Awarded NSF Frontera Computational Science Fellowship for 2025-2026—worth ~\$50000 to use Frontera supercomputer at TACC UT Austin.
- Thesis: Analyzing Timeseries and Dynamical Systems with Topology, Stochastic Theory and Machine Learning.
- 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, MLOps, Computational Optimization

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

Georgia Tech Research Institute

Atlanta, GA, USA

Deep Learning Applied Researcher (Contract - Part Time)

Aug 2025 - ongoing

- Building classifiers to identify pathogen environments from genomic sequence data using dimensionality reduction, deep neural networks, and off-the-shelf LLMs; automating workflows with Github, documenting experiments with MLflow and deploying models through APIs.

PhD Machine Learning Research Intern - Cybersecurity Lab

May 2025 - Aug 2025

- Empirically established a strong correlation (Pearson coefficient = 0.8) between the loss curve and the polyhedral decomposition topology of feature space in ReLU-based Neural Networks, enabling direct use of decomposition for loss value prediction.

Michigan State University

East Lansing, MI, USA

Research and Teaching Assistant

Sept 2022 - May 2026

- Developed data pipelines and machine/deep learning classifiers like Random Forests and SVM to predict epileptic seizures offline—enhancing accuracy to 99% for single-channel EEG with topological features, and to 80% for multi-channel EEG (16% more than traditional features). Used higher-order causal graph methods for online detection of seizure with 80% accuracy using changepoint detection in complexity and topology.
- Automated the detection of change in distribution (data drift) in high-dimensional stochastic systems by developing novel algorithms—integrating topology, Bayesian spatial modeling, and statistical methods—for robust analysis of noisy time series.
- Taught *Computational Modeling and Data Analysis* and *Data Visualization* to undergraduates, guiding in object oriented Python programming, graph theory, time series analysis and machine learning. Overall teaching performance rated 18% above average.
- Independently initiated and designed an unsupervised machine learning algorithm, devising a topology-based loss function, that achieved up to 20% lower Kullback–Leibler Divergence compared to standard bandwidth selection methods in kernel density estimation.
- Cleaned, packaged, and documented code into an open-source Python package, **teaspoon**, using Jupyter Notebooks, GitHub and Sphinx with unit-tests, ensuring reproducibility and knowledge sharing across the team.
- Mentored 2 first-year PhD students with 100% success in their qualification exams; assisted in writing 2 grant proposals leading to winning over \$600K+ in grant money.

Publications

- **Tanweer, S.**, Khasawneh, F.A. & Subrahmaniam, N.P. (2026, March). Epileptic seizure prediction with machine learning and higher-order graph methods. (*In preparation*)
- **Tanweer, S.** & Khasawneh, F.A. (2026, January). Detecting Stochasticity in Discrete Signals via Nonparametric Excursion Theorem. arXiv:2601.06009. Under review at Chaos.
- Timofeyev, T., Potvin, C., **Tanweer, S.**, et al. (2026, January). Asymmetrically Weighted Dowker Persistence and Applications in Dynamical Systems. arXiv:2601.04559. Under review at JACT.
- **Tanweer, S.** & Khasawneh, F.A. (2025, December). P-Bifurcations in Stochastic Flutter Model Under Common Gust Perturbations. arXiv:2512.14678. Under review at Nonlinear Dynamics.
- **Tanweer, S.** & Khasawneh, F.A. (2025, December). Unsupervised Learning of Kernel Density Estimates with Topology Optimization. arXiv:2512.08895. Under review at ICPR 2026.
- **Tanweer, S.**, Khasawneh, F.A., & Mamis, K. (2025, April). TDA for Detection of Phenomenological Bifurcations in Stochastic Epidemiological Models. arXiv:2504.13215. Under review at Mathematical Biosciences.
- **Tanweer, S.**, Bosca, V., Rask, T., Tawfeek, A.R., & Stone, B. (2025). Topological Signatures of ReLU Neural Network Activation Patterns. Equal contribution. Proceedings of the 1st Conference on Topology, Algebra, and Geometry in Data Science (TAG-DS 2025), PMLR.
- Khasawneh, FA., Munch, E., **Tanweer, S.**, et al. (2025, March). Teaspoon: A Python Package for Topological Signal Processing. Journal of Open Source Software. <https://doi.org/10.21105/joss.07243>.
- **Tanweer, S.** & Khasawneh, FA. (2024, May). Topological detection of phenomenological bifurcations with unreliable kernel densities. Probabilistic Engineering Mechanics. <https://doi.org/10.1016/j.proengmech.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.

Conference Talks

- **Invited conference talk:** “Phenomenological Bifurcations in Compartmental Stochastic SIS and SIR Models for Epidemiology”, Joint Mathematics Meetings (JMM), Washington, DC, January 2026.
- “Phenomenological Bifurcations in Compartmental Stochastic SIS and SIR Models for Epidemiology”, SIAM Conference on Applications of Dynamical Systems (DS25). Denver, CO, May 2025.
- “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.

Posters

- “Geometric Trust in AI: A Topological Analysis of ReLU Neural Networks”, IRAD, Georgia Tech Research Institute (July, 2025).
- “Topological Detection Of Phenomenological Bifurcations with Unreliable Kernel Densities”, Engineering Graduate Research Symposium, MSU (May, 2024).
- “Exploring Topological Data Analysis for Identifying Phenomenological Stochastic Bifurcations”, Engineering Graduate Research Symposium, MSU (May, 2023).

Selected Projects

- *Reinforcement Learning:* Implemented a PPO-based reinforcement learning agent for algorithmic stock trading using stable-baselines3 and gymnasium, which achieved a 60+% ROI in a historical backtest on GME data by learning an effective buy-and-sell strategy.
- *Recommender Systems:* Built a matrix-factorization recommender system and trained using SGD, achieving 0.95 test RMSE and strong ranking performance (Hit-Rate@10 = 58%) on MovieLens-100K.
- *Machine Learning:* Implemented the Random Feature Map-based online Machine Learning algorithm for time series forecasting, with 5x speedup.
- *Time Series Forecasting:* Predicted stock price for CrowdStrike using methods like ARIMA, stochastic modeling and LSTM neural network, with stochastic model showing 40% and LSTM showing 80% less error than ARIMA.
- *Optimization:* Ran a Monte Carlo study of SGD stochasticity in CNN training, showing that minibatch-induced noise acts as implicit regularization, improving test accuracy by 4-5%, while injected Gaussian gradient noise destabilized optimization and caused 20-30% performance degradation.
- *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 n Bayesian Point Processes using OpenMP and MPI for n times speedup.
- *Deep Learning:* Built an e-commerce multiclass clothing classifier using CNN with PyTorch, achieving 89% accuracy.
- *Differential Equations:* Validation of closed-form expressions for crossing rate in narrow-band random processes.

Skills

Programming	Python (Statsmodels, scipy, scikit, PyTorch/TensorFlow, gymnasium, mlflow), C++, MATLAB, Parallel Computing (SLURM)
Computer Aided Design	ProEngineer / Creo, Soliworks, AutoCAD, SpaceClaim/DesignModeler
ML and Applied Science	Statistical Methods, Time Series Analysis, Hypothesis Testing, Stochastic Models, Monte Carlo Simulations, Optimization
Software Development	Sphinx (documentation), Markdown (documentation), Git (version control), Unit Testing, \LaTeX

Trainings

- **Train-the-Trainer T4DS** training (06-20-2023) on managing and training students in topological data analysis: 1 of the 9 funded participants.
- **CIRTL Supporting Neurodivergent Students** (11-08-2023) on forms of neurodiversity, problems faced by neurodiverse students and methods of supporting them.

Awards and Leadership

- Secretary for ME-Graduate Student Association for Fall 2025 - Spring 2026.
- Awarded NSF Frontera Computational Science Fellowship for 2025-2026—worth ~ \$50000.
- 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.
- Special Mention in South Asia Model United Nation (SAMUN) 2017 for UN-Security Council.