Aniket Deshpande

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Researching quantum information, learning theory, and theoretical neuroscience.

Education

University Of Illinois, Urbana-Champaign Urbana, IL

B.S. Physics, Specialization in Mathematical Physics 2023 – 2027 *(expected)*

- *Graduate:* High-Dimensional Statistics$^{\mathcal{I}}$, Dynamical Systems$^{\mathcal{I}}$, Measure Theory$^{\mathcal{I}}$, Representation Theory$^{\mathcal{I}}$
- *Undergraduate:* Machine Learning Theory$^{\mathcal{I}}$, Data Structures & Algorithms, Quantum Information Processing, Electromagnetic Fields, Classical Mechanics, Special Relativity

$^{\mathcal{I}}$ *denoting in progress*

Talks & Posters

Approximating Tensor Contractions with Annealed Importance Sampling, *08.2025*

Poster developed for QSim 2025, New York, NY

- Implemented Annealed Importance Sampling (AIS) with Markov Chain Monte Carlo (MCMC) to efficiently approximate tensor network contractions.
- Analyzed algorithmic accuracy and convergence behavior across tensor difficulties, highlighting AIS advantages over uniform sampling in challenging regimes.
- Identified minimal mixing requirements for optimal AIS performance, paving the way toward scalable contraction algorithms for quantum simulation.

Quantum Circuit Volume for Graph Models, *Illinois Math Lab Open House* *12.2024*

Poster developed with the *Illinois Mathematics Lab*

- Developed quantum circuits simulating birth-death process graph channels with optimized resource scaling using EQ_k, P_k, and RY gates.
- Established $O(\sqrt{n}) \leq l(\Phi) \leq O(n)$ bounds on simulation cost via Lipschitz complexity and Kraus rank methods.
- Optimized circuit depth ($O(n \log n)$) and ancilla space ($O(n)$) under locality constraints, presenting a general framework for graph channel simulation.

Research

Computation & Neurodynamics Lab | Urbana, IL 01.2025 – Present

- Simulating heterogeneous FitzHugh–Nagumo neuron networks under noisy time-varying inputs; analyzing intrinsic timescale covariances and applying neural-symbolic regression to uncover interpretable governing equations.
- Deriving Lie brackets between closure ODEs and infinitesimal generators to identify symmetry-preserving perturbations and neural code invariants via geometric and algebraic methods.
- PI: Dr. Matthew Singh

Lab for Parallel Numerical Algorithms | Urbana, IL 09.2024 - Present

- Collaborating on the development of a novel Monte Carlo algorithm for contracting general tensor networks, with applications to quantum circuit simulation.
- Investigating randomized methods such as TensorSketch for efficient estimation of trace-like quantities in large-scale tensor networks.
- PI: Dr. Edgar Solomonik

Polymer Physics Theory Group | Urbana, IL 08.2024 - 01.2025

- Performed computational simulations of free-draining bottle brush polymers with explicit side-chains using a coarse-grain model
- Refactored and improved coarse-grain model using stochastic differential equations and brownian motion results. Implemented the model in `C`.

Industry

Space Dynamics Laboratory | Ionospheric Analyst Intern 05 - 08.2024

- Developed a `Python` scraper to expedite the data collection of NICT ionograms to $600+$ ionograms downloaded per hour.
- Researched numerical analysis methods to improve the noise reduction of ionograms using various filtering methods. Implemented filters in `Python` and `Julia` and ran statistical analysis (PSNR, MSE, SSIM) to compare efficiencies.
- Researched methods to improve automatic ionogram scalers using deep learning architecture (CNNs) and techniques.

Learning

Independent Study– ***Neural Operators for Neuroscience***, *0.8.2025-Present*
with Dr. Matthew Singh

QSim Summer School – ***NSF RQS (hosted at IBM, NYC)***, *08.2025*
Lectures covering theoretical and experimental perspectives on quantum error correction, simulation, and algorithms.

Uncertainty Quantification & Machine Learning for Physical Systems – *05.2025*
IMSI hosted at the University of Chicago,
Lectures on Bayesian inference, sensitivity analysis, and physics-informed neural networks, with applications to complex physical systems.

LPNA Reading Group – ***University of Illinois***, *01.2025 – Present*
Weekly discussions on random matrix theory, graph partitioning, tensor network applications, and quantum error correction.

Outreach

Membership Director *SIAM @ University of Illinois*, *05.2025 - Present*
SIAM@UIUC executive officer. Responsibilities include managing membership status, involvement, and recruitment.

Professional Affiliations

Society of Industrial & Applied Mathematics, *05.2025 - Present*
Member

Skills

Programming: Python, C/C++, Java, Julia, Mathematica

Scientific Computing: Numerical simulation, stochastic modeling, time series analysis, statistical signal processing, sliding window statistics, ODE/SDE solvers

Libraries & Frameworks: NumPy, SciPy, Pandas, Matplotlib, scikit-learn, SymPy, Jupyter

Tools & Environments: Git, LaTeX, Conda, Shell, Jupyter