Faranak Rajabi

Ph.D. Candidate, Mechanical Engineering & M.S. Computer Science, UC Santa Barbara

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PhD candidate in Mechanical Engineering and Computer Science at UC Santa Barbara. Specializing in high-performance PDE solvers, stochastic optimal control, and multiscale modeling of continuum media. Experienced in parallel C++/PETSc development, adaptive mesh refinement, and CPU-accelerated numerical methods. Passionate about applying computational physics to simulation, planning, and acoustics in large-scale systems.

Education

University of California, Santa Barbara **Santa Barbara, CA**
Ph.D. in Mechanical Engineering (GPA: 3.94/4.00) *Jan. 2022 – Present*

- **Dissertation:** *"Advanced Computational Methods for Complex Biological Systems"*
- **Advisors:** Dr. Frédéric Gibou and Dr. Jeff Moehlis, Computational Applied Science Laboratory.
- **Graduate Coursework:** Numerical Simulation with ODEs, Finite Difference Methods for PDEs, Applied Dynamical Systems, Linear Systems Theory, Kalman & Adaptive Filtering, Advanced Matrix Computations, Stochastic Processes.

University of California, Santa Barbara **Santa Barbara, CA**
M.S. in Computer Science (GPA: 4.00/4.00) – Concurrent Degree *Aug. 2023 – Present*

- Concurrent degree program strengthening theoretical and computational foundations for large-scale scientific computing and AI.
- **Core Coursework:** Runtime Systems, Distributed Systems, Data Structures, Advanced Theory of Optimization and Applications, Machine Learning: Signal Processing Approach, Level Set Methods, Group Studies: Cybersecurity and Extended Reality.

Research Experience

Graduate Research Assistant **Jan. 2022 - Present**
Computational Applied Science Laboratory, UC Santa Barbara *Santa Barbara, CA*

- **CASL-HJX Computational Framework:** Developed **CASL-HJX**, a high-performance C++/PETSc framework for solving deterministic and stochastic Hamilton–Jacobi equations. Implemented WENO/ENO schemes, operator splitting, and implicit parabolic solvers to ensure convergence to viscosity solutions. Published in *Computer Physics Communications*.
- **Stochastic Optimal Control & Dynamical Systems:** Applied CASL-HJX to compute optimal feedback strategies for stochastic neural oscillators. Designed event-driven controllers and optimization methods with results published in *Biological Cybernetics* and IEEE CDC 2025.
- **Multiscale Physics Simulation (Protein Aggregation):** Built computational models coupling molecular-scale protein dynamics with continuum PDEs to predict aggregation in biotherapeutics. Collaborated with industry (Merck) for validation against experimental data. Framework extends to general transport and diffusion modeling.
- **Machine Learning for Scientific Computing:** Integrated physics-informed neural networks and signal-processing-based ML methods with PDE solvers for time-series prediction and control optimization. Combined data-driven and physics-based approaches to improve accuracy and robustness in simulation tasks.

Technical Skills

PDEs & Scientific Computing: Deterministic and stochastic Hamilton–Jacobi equations, optimal control, advanced PDE solvers (Poisson, heat, Stefan, level-set methods), numerical optimization algorithms, Monte Carlo methods, multiscale transport and diffusion modeling

Programming & Software Engineering: C++ (high-performance development with PETSc/MPI), Python (NumPy, SciPy, JAX), MATLAB, R, Linux/Unix systems, version control (Git), software testing and deployment

High-Performance Computing: Parallel algorithm development, adaptive mesh refinement, distributed system design, performance profiling and optimization, memory management, scalable architectures on multi-core and cluster environments

Machine Learning & Data Science: Physics-informed neural networks, PyTorch, TensorFlow, statistical signal processing, data-driven modeling, feature engineering, model validation, real-time prediction and control

Teaching & Leadership Experience

Graduate Teaching Assistant **Apr. 2022 - Present**
UC Santa Barbara - Mechanical Engineering & Computer Science *Santa Barbara, CA*

- Instructed 1000+ students in computational methods, numerical analysis, and scientific computing
- Developed algorithmic problem-solving curricula adopted as standard department materials; improved average student performance by 15%
- Mentored 10+ undergraduate research projects in quantitative computing, resulting in 2 conference presentations

Academic Leadership & Professional Service **Sept. 2023 - Present**
UC Santa Barbara & Professional Organizations *Santa Barbara, CA & Remote*

- **APS Career Mentor Fellow**: Mentoring 20+ students annually in STEM career development and quantitative fields
- **Peer Reviewer**: Journal of Computational Physics - evaluated manuscripts in numerical methods and computational mathematics

Publications & Technical Presentations

- **Peer-Reviewed Publications:**
  - **F. Rajabi**, J. Fingerman, A. Wang, J. Moehlis, and F. Gibou, "CASL-HJX: A Comprehensive Guide to Solving Deterministic and Stochastic Hamilton-Jacobi Equations," *Computer Physics Communications*, in press (2025).
  - **F. Rajabi**, F. Gibou, and J. Moehlis, "Optimal Control for Stochastic Neural Oscillators," *Biological Cybernetics*, vol. 119, article no. 9, 2025.
  - M. Zimet, **F. Rajabi**, and J. Moehlis, "Nearly Optimal Chaotic Desynchronization of Neural Oscillators," *Proceedings of the 64th IEEE Conference on Decision and Control (CDC)*, December 2025.
  - J. Moehlis, M. Zimet, and **F. Rajabi**, "Magnitude-Constrained Optimal Chaotic Desynchronization of Neural Populations," *Frontiers in Network Physiology*, accepted 2025.
- **To be submitted:**
  - **F. Rajabi** and F. Gibou, "Solving Diffusion-Type Equations with Robin Boundary Conditions on Piecewise Smooth Interfaces," *Journal of Computational Physics*, to be submitted 2025.
- **Conference Presentations:**
  - "Optimal Control for Stochastic Neural Oscillators," *SIAM Conference on Applications of Dynamical Systems*, Denver, CO, May 2025.
  - "A Level-Set Method Approach to Optimally Control Stochastic Neural Oscillators," ResearchGate Conference, 2023 [Link]

Technical Projects

- **CASL-HJX Computational Platform** [GitHub]: High-performance C++ toolkit for deterministic and stochastic Hamilton-Jacobi PDEs with real-time optimization applications. Designed for distributed computing environments supporting thousands of cores 2023–Present
- **Stochastic Control Systems** [GitHub]: MATLAB-based event-driven controllers and HJB equation solvers for noisy dynamical systems with real-time optimization algorithms applicable to quantitative finance 2022–2024
- **ML Control Optimization**: Developed ML-based adaptive control systems using autoencoders and deep learning for signal processing and optimization, achieving significant performance improvements in real-time decision systems 2024–2025
- **Advanced Numerical Solvers** [GitHub]: Comprehensive finite difference implementations for complex PDEs with high-order accuracy schemes and adaptive refinement capabilities 2022–2024

Honors & Recognition

- **UCSB Graduate Summer Fellowship** (2022, 2023, 2024, 2025) – Competitive research funding for top-tier PhD candidates
- **UCSB Conference Travel Grant** (Spring 2025) – Competitive funding for research presentation at premier conference
- **UCSB Computer Science Tuition Fellowship** (2023) – Full tuition waiver for outstanding academic performance
- **UCSB Block Grant** (2022) – Merit-based award for top incoming PhD students