Sina Rezazadeh Baghal

PhD in Mathematics (Optimization)

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About me

I earned my Ph.D. in Mathematics (Optimization) from the University of Waterloo in 2021, following both my Master's and Bachelor's degrees in Mathematics from Sharif University of Technology. My doctoral research centered on Stochastic Optimization, while my earlier studies explored Fundamental Mathematics.

Beyond my academic work, I enjoy tackling challenging projects that draw on a broad range of applied sciences. I'm passionate about prototyping complex algorithms and have a strong hands-on programming experience, particularly with Python and PyTorch. My deep theoretical foundation enables me to design and implement advanced solutions efficiently and effectively.

Development Projects

- **Solving Pasur Using GPU-Accelerated Counterfactual Regret Minimization** (arXiv Preprint)

  In this project, I develop a CUDA-accelerated computational framework for simulating Pasur, emphasizing efficient memory management. I use this framework to compute near-Nash equilibria via Counterfactual Regret Minimization (CFR), a well-known algorithm for solving large imperfect-information games.

  Tags: Reinforcement Learning | Artificial Intelligence | Counterfactual Regret Minimization | Efficient Computing | PyTorch | Game Theory | GPU Optimization | Memory Management | Nash Equilibrium

- **Generative Modeling of Heston Volatility Surfaces Via Variational Autoencoders** (Project Page, Code)

  This project focuses on training a Variational Autoencoder (VAE) to produce Heston Volatility Surfaces. The Heston model is used in stochastic volatility option pricing models. Once trained, this VAE can generate new volatility surfaces, which could be useful for various financial applications.

  Tags: Deep Learning | Generative AI | Variational Autoencoder | PyTorch | Heston | Volatility Surfaces | Vectorization | Monte Carlo Simulation | Numerical Analysis | Optimization | Option Pricing

- **Implementing Deep Smoothing for Implied Volatility Surfaces** (Project Page, Code)

  This project is a Python-based implementation of the methodologies presented in the paper Deep Smoothing of the Implied Volatility Surface by Ackerer et. al. with different aspects related to the neural network training, convergence behavior, and associated implementation details developed independently.

  Tags: Deep Learning | Generative AI | Feed Forward Networks | PyTorch | Volatility Surfaces | Vectorization | SSVI | Convex Optimization | CVX | Fine-tuning | Option Pricing

Work Experience

- **TD (Data Scientist III)** Jul 23 - Present

  Current position

  - **Delivery**: Develop models to analyze customer behavior by identifying patterns within large historical datasets. The projects cover all products in the banking portfolio and are utilized by the financial crime risk management team to detect fraudulent activities. Contribute significantly to various information technology projects, including data visualization and performance evaluation (backtesting) of models.

    Tags: Python | PySpark | SQL | SAS | Problem Solving | Modeling | Data Science

CIBC (Quantitative Analyst) Aug 22 - Jul 23

- **Delivery (FRTB IMA)**: Non-Modellable Risk Factor Time Series Construction: Developed tools and methodology for time series construction of credit derivative risk factors such as single-name CDS spreads, Sector CDS spreads, CDS Index Spreads and CDS Index Volatilities. Developed methodology to identify proxy/reduced-set time series. Developed OOP style Python package using bash scripting and parallel processing to handle large data and ensure maintainability

  Tags: Mathematical Finance | FRTB | Python | Performance Optimization | Parallel Processing | OOP

Huawei Noah's Ark Lab (Machine Learning Researcher) Feb 22 - Aug 22

- **Delivery**: Acceleration of neural networks' SoftMax layer for both training and inference in Pytorch. Achieved baseline accuracy using only the optimal number of bits required for classification i.e., $\lceil \log_2 c \rceil$ where c is the number of classes
- **Research and Collaboration**: Ideal bit-allocation for training different layers of NNs, batch-norm quantization, impact of weights distributional assumptions on quantization, exploding/vanishing gradients, binarization of transformers

  Tags: Deep Learning | Pytorch | Quantization

University of Waterloo (Postdoc (CS), Grad (C&O)) May 16 - Feb 22

- **Research**: Conducted research in stochastic optimization and graph neural networks
- **Teaching**: Semi-definite Programming, Fundamental of Optimization, Introduction to Optimization, Portfolio Optimization, Deterministic OR Models

Tags: Numerical Analysis | Integer Programming | Optimization | Statistics | Machine Learning | Python | CPU/GPU | C++ | MATLAB | Parallel Processing | Dask | Spark | Code Performance Optimization | OOP

Young Scholars Club (Seasonal Mathematical Olympiad Coach (Iran)) Sep 06 - May 16

- **Teaching**: Algebraic Combinatorics, Analytic Number Theory, Probability Theory, and Algebra
- **Problem Solving**: Held challenging problem solving (e.g., Putnam) sessions so students develop their math. skills
- **Problem Design**: Part of problem designing committee for Iranian mathematical Olympiad exams

Tags: Problem Solving | Mathematical Olympiad | Problem Design

Academic Projects

- **Solution Manual to Stochastic Calculus for Finance II** (Manuscript)

  Stochastic Calculus for Finance II is one of the most accessible books in mathematical finance. The prerequisites for understanding the material include familiarity with graduate-level probability theory and solid knowledge of mathematical analysis. I have written a complete solution manual for all the exercises in this book.

  Tags: Mathematics | Stochastic Calculus | Option Pricing | Finance | Probability Theory

- **A Matrix Concentration Inequality for Products** (arXiv Preprint)

  We present a *non-asymptotic concentration inequality* for the random matrix product

  $$Z_n = (I_d - \alpha X_n)(I_d - \alpha X_{n-1}) \cdots (I_d - \alpha X_1),$$

  where $\{X_k\}_{k=1}^{+\infty}$ is a sequence of bounded independent random positive semidefinite matrices where $\mathbb{E}[X_k] = \Sigma$.

  Tags: Mathematics | High Dimensional Statistics | Probability Theory

- **A Termination Criterion for Stochastic Gradient Descent for Binary Classification** (arXiv Preprint)

  Early stopping rules play a central role in machine learning. This work presents a computationally inexpensive termination criterion, backed by theoretical results, which exhibits a good degree of predictability on yet unseen data. Presented at NeurIPS Optimization Workshop and Conference on Optimization at Fields Institute.

  Tags: Stochastic Gradient Descent | Mixture of Gaussians | Machine Learning | Early Stopping | Markov Chains | Stochastic Stability

Education

- **University of Waterloo** May 16 - Apr 21
  PhD in Mathematical Optimization at the department of Combinatorics & Optimization

- **Sharif University of Technology** Sep 06 - Jul 12
  Bachelor's and Master's degree in Fundamental Mathematics

Selected Honors and Awards

International Scientific Olympiad in Mathematics (Silver Medal, 2010). Iranian Math. Olympiad (Silver Medal, 2005)[1]

[1] Olympiad medals are awarded annually to 40 out of 320,000 competing students