Amartya (Marty) Mukherjee

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Research Interests

My research centers on the intersection of deep learning and stochastic processes, addressing challenges in time series analysis, filtering, and optimal control. I am particularly intrigued by the flexibility of diffusion models and neural operators in bridging the gap between formal methods and machine learning algorithms.

Education

University of Waterloo **September 2022 – April 2027 (Expected)**
Doctor of Philosophy, Applied Mathematics, Supervisor: Jun Liu

University of Waterloo **September 2017 – April 2022**
Bachelor of Mathematics, Applied Mathematics with Scientific Computing, Minor in Statistics

Preprints

- **Amartya Mukherjee**, Ruizhi Deng, He Zhao, Yuzhen Mao, Leonid Sigal, Frederick Tung (2025). *ADiff4TPP: Asynchronous Diffusion Models for Temporal Point Processes.* Submitted to ICLR 2026. arxiv:2504.20411
- **Amartya Mukherjee**, Melissa Stadt, Lena Podina, Mohammad Kohandel, and Jun Liu (2024). *Denoising Diffusion Restoration Tackles Forward and Inverse Challenges in the Laplacian Operator.* Submitted. arxiv:2402.08563
- Milad Farsi, Ruikun Zhou, **Amartya Mukherjee**, Christopher Song, Ye Yuan, and Jun Liu (2024). *Online Model-based Reinforcement Learning for Optimal Control with Provable Stability Guarantees.* Submitted. [Link]

Publications

- **Amartya Mukherjee**, Thanin Quartz, and Jun Liu (2025). *Manifold-Guided Lyapunov Control with Diffusion Models.* American Control Conference (ACC 2025). arxiv:2403.17692
- Yiming Meng, Ruikun Zhou, **Amartya Mukherjee**, Maxwell Fitzsimmons, Christopher Song, and Jun Liu (2024). *Physics-Informed Neural Policy Iteration: Algorithms, Convergence, and Verification.* 41st International Conference on Machine Learning (ICML 2024). [Link]
- **Amartya Mukherjee** and Jun Liu (2024). *Enhancing Reinforcement Learning in Vision-Based Environments with Optical Flow.* Journal of Computational Vision and Imaging Systems, 9(1), 1–3. DOI: https://doi.org/10.15353/jcvis.v9i1.10000
- **Amartya Mukherjee** and Jun Liu (2023). *Actor-Critic Methods using Physics-Informed Neural Networks: Control of a 1D PDE Model for Fluid-Cooled Battery Packs.* ICML Workshop on New Frontiers in Learning, Control, and Dynamical Systems. [OpenReview]
- **Amartya Mukherjee** and Jun Liu (2023). *Bridging Physics-Informed Neural Networks with Reinforcement Learning: Hamilton-Jacobi-Bellman Proximal Policy Optimization (HJBPPO).* ICML Workshop on New Frontiers in Learning, Control, and Dynamical Systems. [OpenReview]
- **Amartya Mukherjee**, Yusuf Aydogdu, Thambirajah Ravichandran, and Navaratnam Sri Namachchivaya (2022). *Stochastic Parameterization Using Compressed Sensing: Application to the Lorenz-96 Atmospheric Model.* Tellus A: Dynamic Meteorology and Oceanography, 74(2022), pp.300–317. DOI: http://doi.org/10.16993/tellusa.42

Patents

- Sheral Kumar, **Amartya Mukherjee**, Seel Patel, Rui Xiang Chai, Wentao Liu, Yuanhao Yu, Yang Wang, Jin Tang. *Methods and Devices for Extracting Motion Vector Data from Compressed Video Data.* US Patent 11,729,395 B2, filed November 26, 2021, published August 15, 2023. [Google Patents]

Research Internship Experience

Machine Learning Research Intern, Borealis AI **Sep 2024– Jan 2025**

Mentor: Dr. Frederick Tung

- Developed a generative modeling framework for time series that can flexibly handle arbitrary splits between observed and predicted events, prioritizing accurate forecasting of near-future events.
- Designed an asynchronous noise schedule in the diffusion process to model event sequences more efficiently than standard synchronous approaches.
- Combined a transformer-based variational autoencoder for learning event representations with a diffusion-based transformer for sequential prediction.
- Formulated partial differential equations linking the diffusion process to the stochastic prediction of future events given past observations.

Computer Vision, Noah's Ark Lab at Huawei Technologies Canada **May 2021– Dec 2021**

Mentor: Dr. Wentao Liu

- Implemented solutions for accelerating video AI tasks on smartphones by focusing on motion vector extraction.
- Integrated customized H.264 and HEVC video decoders into the Android Media framework, enabling the extraction of motion vector information from video streams.
- Achieved significant performance improvements by reducing computation times for optical flow and action recognition models by 55% and 34%, respectively, through the efficient use of motion vector data.

Fields CQAM Laboratory for Inference and Prediction **May 2020– Apr 2021**

Mentor: Professor N. Sri Namachchivaya (Department of Applied Mathematics, University of Waterloo)

- Developed a data-driven stochastic parameterization framework for multi-scale atmospheric models to represent unresolved small-scale dynamics in terms of resolved variables.
- Integrated sparse optimization and auto-regressive noise modeling, demonstrating that compressed sensing with stochastic residual modeling outperforms traditional polynomial regression in trajectory forecasting and distribution matching.
- Reduced the mean squared prediction error of Rossby waves by 21% using Compressed Sensing and further by 64% using Ensemble Kalman Filter.

Teaching Experience

MATH 237 - Calculus 3 for Honors Mathematics **May 2025– Aug 2025**

Course Instructor and Coordinator - Faculty of Mathematics

- Designed and authored assignment and examination questions, drawing inspiration from statistics, convex optimization, and partial differential equations to motivate and engage students.
- Provided academic support through regular office hours, addressing student questions, and drawing applications from my research.

AMATH 495/900 - Mathematics of Climate Change **Jan 2025– Apr 2025**

Teaching Assistant - Department of Applied Mathematics

- Graded and assisted students with research projects in statistical and machine learning methods for climate models, including LSTMs, temporal point processes, stochastic parameterization, and Brownian bridges.
- Reviewed students' Python code for the implementation of discrete Fourier, wavelet, and random forest methods applied to climate datasets.

AMATH 731 - Applied Functional Analysis **Sep 2023– Dec 2023**

Teaching Assistant - Department of Applied Mathematics

- Assisted with curriculum development by providing expertise on topics like Sobolev spaces and Ritz method that the instructor was less familiar with.
- Collaborated closely with the course instructor in writing relevant assignment and exam questions.
- Assisted students with research projects on applications of functional analysis in quantum physics, economics, and computer graphics.
- Wrote marking schemes for assignments and designed grade distributions.

Notable Software Internships

Data Scientist **Jan 2020– Apr 2020**
Zeitspace *Waterloo, ON, Canada*

- Implemented an automated rider sorting system for races based on skill levels, leveraging unsupervised learning techniques.
- Employed the TrueSkill algorithm to assess rider rankings, using historical race results to determine skill levels accurately.
- Used K-Means Clustering to group riders with similar ranks and experience into the same race, creating a more competitive and engaging racing experience.
- Deployed the algorithm to the backend of the system, using Python in conjunction with Flask.

Presentations

Department Learning Seminars

- *Reinforcement Learning: Zero to ChatGPT* [Slides]
  Hosted a Machine Learning seminar for students and faculty in the Department of Applied Mathematics, University of Waterloo. The presentation provided an introductory journey into reinforcement learning, exploring key concepts such as proximal policy optimization (PPO) and reinforcement learning with human feedback (RLHF). The talk highlighted the practical application of these techniques in training large language models (LLMs), using ChatGPT as a case study.

Honors and scholarships

- American Control Conference Student 2025 Travel Grant - 650 USD
- University of Waterloo Graduate Scholarship - 1,000 CAD
- International Conference on Machine Learning 2023 Student Travel Grant - 1,030 USD
- President's Scholarship (University of Waterloo) - 2,000 CAD
- Founder's Scholarship (K. International School Tokyo) - 300,000 JPY

Technical Skills

Programming languages
Python, Matlab, Julia, C++, C, SQL, Java, R
Software
LaTeX, Git, Flask, PyTorch, OpenCV, PySindy, PySpark, FEniCS
Languages
English (fluent), Japanese (N3), Mandarin (basic)