Deepanshu Verma

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Education

Doctor of Philosophy, Computational Math — Aug 2018 – Aug 2021
George Mason University, Fairfax, VA, USA — *GPA: 4.0/4.0*
Advisor: Dr. Harbir Antil

Master of Science, Mathematics — 2015-2018
Indian Institute of Technology, Bombay, India — *CPI: 9.65/10*

Bachelor of Science, Mathematics — 2012-2015
University of Delhi, New Delhi, India — *Percent Grade: 95%*

Professional Experience

Distinguished Visiting Assistant Professor — August 2021 – Present
Emory University, Atlanta, GA, USA

- Conduct innovative research in optimal control with a focus on using Neural Networks as function approximators under the guidance of Dr. Lars Ruthotto.
- Create Python packages for implementing deep learning techniques to solve high-dimensional Hamilton-Jacobi-Bellman problems.
- Collaborate with interdisciplinary teams to address complex scientific challenges, and present findings at national and international conferences.
- Provide mentorship and guidance to graduate and undergraduate students alongside the supervisor.
- Played an instrumental role in the REU/RET site, enhancing the research capabilities and reputation of the department.
- Active participation in departmental seminars, workshops, and other academic activities, contributing to the intellectual environment of the institution.
- Instruct two courses annually during the academic year.

Graduate Research Assistant — Aug 2018 – Aug 2021
Department of Mathematics, George Mason University, Fairfax, VA, USA

- Managed several applied and methodological research projects under supervision.
- Developed MATLAB packages for implementing machine learning and PDE-constrained optimization methods.
- Assisted in conducting literature reviews on advanced mathematical and machine learning techniques, preparing comprehensive reports with data analysis and visualization to support academic pursuits.

Summer Graduate Computing Student Intern — May 2021 – Aug 2021
Lawrence Livermore National Lab, Livermore, CA, USA

- Evaluated existing methods for approximating the Signed Distance Function (SDF) used to determine the distance of a point from the boundary of a surface.
- Developed an SDF solver in MFEM, a C++ library for finite element methods.

Research Projects

Deep Learning for Optimal Control

- Enhanced learning algorithms utilizing control theory to solve high-dimensional optimal control problems through the Hamilton-Jacobi-Bellman equation. This unsupervised learning method informs decision-making in deep brain simulations, finance, robotics, and more.
- Developed a novel learning algorithm combining HJB and finite element methods (FEM) to address PDE-constrained optimization in applications like contaminant containment and wildfire control.
- Demonstrated the superiority of the HJB approach over Reinforcement Learning for various applications.

Enhancing Deep Learning with Control Strategies

- Introduced the fractional-DNN method, employing fractional calculus to mitigate the vanishing/exploding gradient issue in deep learning.
- Utilized PDE-constrained optimization techniques in DL for dynamical data analysis and modeling.
- Designed deep learning algorithms to learn dynamics in stiff ODEs (chemical reactions), Navier-Stokes equations and Hamiltonian differential equations (Hamiltonian mechanics).

Optimal Control of Fractional PDEs

- Investigated external source identification problems within optimal control, including the development of functional analytic tools for solution existence and uniqueness.
- Conducted error analysis for FEM and created MATLAB packages for solving these problems efficiently.

Publications

- L. Ruthotto, **D. Verma**, N. Winovich, and B. v Bloemen Waanders. Amortized PDE control with HJB and Reinforcement Learning. *In preparation.*
- Z. Wang, R. Baptista, Y. Marzouk, L. Ruthotto and **D. Verma**. Neural Network approaches for conditional sampling and density estimation motivated by optimal transport. *In preparation.*

- **(advised)** E. Hayes, M. Heider and C. Vanty. HINNs: Hamiltonian Inspired Neural Networks. *In preparation.*
- M. Madondo, **D. Verma**, L. Ruthotto, and N. A. Yong (2023). Learning Control Policies of Hodgkin-Huxley Neuronal Dynamics. Submitted to *ML4H*. B. P. Lamichhane, N. Nataraj, and **D. Verma**. (2023) A mixed finite element method using a biorthogonal system for optimal control problems governed by a biharmonic equation. Accepted in *ANZIAMJ 2023*.
- H. Antil, H.C. Elman, A. Onwunta, and **D. Verma**. (2023) A deep neural network approach for parameterized PDEs and Bayesian inverse problems. *Mach. Learn.: Sci. Technol. 4 035015*. DOI: Link
- X. Li, **D. Verma** and L. Ruthotto. (2022) A Neural Network approach for Stochastic Optimal Control problems. arXiv
- H. Antil, T.S Brown, R. Löhner, F. Togashi, and **D. Verma**. (2022) Deep Neural Nets with Fixed Bias Configuration. *Numer. Algebra Control Optim*. DOI: Link
- T.S. Brown, H. Antil, R. Lohner, F. Togashi, and **D. Verma**. (2022) Parallel Deep ResNets for Chemically Reacting Flows. *AIAA SciTech Forum*. DOI: Link
- H. Antil, R. Khatri, R. Löhner and **D. Verma**. (2020) Fractional Deep Neural Network via Constrained Optimization. *Machine Learning: Science and Technology 2020*. DOI: Link
- H. Antil, T.S. Brown, **D. Verma** and M. Warma. (2021) Optimal Control of Fractional PDEs with State and Control Constraints. Accepted in *Pure and Applied Functional Analysis*. arXiv
- H. Antil, **D. Verma** and M. Warma. (2020) Optimal Control of Fractional Elliptic PDEs with State Constraints and Characterization of the dual of Fractional Order Sobolev Spaces. *J Optim Theory Appl*. DOI: Link
- H. Antil, **D. Verma** and M. Warma. (2020) External Optimal Control of Space-Time Fractional Parabolic PDEs. *ESAIM: COCV 26 (2020) 20*. DOI: Link

Awards and scholarships

George Mason University

- Dean's Graduate Award for Excellence — 2019-2020
- Presidential Merit Fellowship — 2018-2021
- Presidential Scholar Summer Research Fellowship — 2020

Indian Institute of Technology, Bombay

- Institute Silver Medal — Aug 2017
- Mrs. Rama Mathur Award — Aug 2017
- Prof. P.V. Sukhatme Memorial Prize Award — Aug 2017
- Institute Academic Prize — Aug 2016

Skills

- **Research:** Research methodology & design; machine learning; finite element methods; numerical optimization; written and oral presentation; communication and interpersonal skills
- **Software:** Proficient in FEniCS, PyTorch, Python, Matlab, MS office with Basic Proficiency in C++

Research Interest

- Numerical Analysis
- Scientific Computing
- Optimization
- Deep Learning
- Inverse Problems
- Optimal Control

Mentorship

- Oliver Wang — **Emory Honors Program** — Summer 2022 - May2023
  Current: *Ph.D student in Aeronautics and Aeronautics at MIT, August 2023*
- Sylvia Vincent — **Masters Thesis, IIT Bombay** — August 2022 - May2023
  Current: *Ph.D student in Statistical Sciences at Duke University, August 2023*
- **Emory REU Mentees** — Summer 2022
  Emma Hayes — Carnegie Mellon University
  Mathias Heider — University of Delaware
  Current: *Masters in CS at University of Delaware*
  Carrie Vanty — Middlebury College

Leadership

- **Executive Board member**, Emory REU/RET Computational Mathematics for Data Science. Summer 2022
  Organized tutorials, seminars, professional development opportunities; designed the REU/RET schedule, deliverables; and support of logistics.
- **Minisymposia co-organiser**, various national and international conferences.
- **Executive Board member**, SIAM GMU Student Chapter. August 2019-2021
- **Support Team Member & SIAM Representative,** East Coast Optimization Meeting. August 2019-2021
- **Poster Judge**, SIAM conference on Mathematics of Data Science, San Diego, CA. September 2022
- **Student Coordinator**, PDE-Control Seminar, George Mason University. August 2019-2021
- **Core Member of Public Relations Team,** Mathematics Olympiad, IIT Bombay, India**.** July 2016-2017
  Conceptualized a mathematics talent search test for high school and under-graduate students.