Avik **Pal**

Ph.D. Candidate · Massachusetts Institute of Technology

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Education

Massachusetts Institute of Technology — *Cambridge, USA*

S.M. & Ph.D. in Electrical Engineering and Computer Science, GPA: **4.9 / 5.0** — *Sept. '21 – Dec '25 (est.)*

- Advisors: Dr. Alan Edelman, & Dr. Chris Rackauckas
- Masters' Thesis: *On Efficient Training and Inference of Neural Differential Equations*

Indian Institute of Technology Kanpur — *Kanpur, UP, India*

Bachelor of Technology (B.Tech.) in Computer Science and Engineering, GPA: **9.9 / 10.0** — *July '17 – May '21*

Publications

428 citations across all publications and preprints.

Conference Proceedings

Locally Regularized Neural Differential Equations: Some Black Boxes Were Meant to Remain Closed!

Avik Pal, Alan Edelman, & Chris Rackauckas — *2023*

International Conference on Machine Learning (ICML)

Continuous Deep Equilibrium Models: Training Neural ODEs Faster by Integrating Them to Infinity

Avik Pal, Alan Edelman, & Chris Rackauckas — *2023*

IEEE High Performance Extreme Computing (HPEC) **(Best Student Paper Award)**

Opening the Blackbox: Accelerating Neural DEs by Regularizing Internal Solver Heuristics

Avik Pal, Yingbo Ma, Viral B. Shah, & Chris Rackauckas — *2021*

International Conference on Machine Learning (ICML)

Emergent Road Rules In Multi-Agent Driving Environments

Avik Pal, Jonah Philion, Andrew Liao, & Sanja Fidler — *2021*

International Conference on Learning Representations (ICLR)

Accelerating Stiff Pharmacology Models: Continuous-Time ESNs as Implicit ML

Ranjan Anantharaman, Anas Abdelrehim, Anand Jain, Avik Pal, Danny Sharp, Utkarsh, & Chris Rackauckas — *2021*

International Federation of Automatic Control (IFAC)

Composing Modeling and Simulation with Machine Learning in Julia

Chris Rackauckas, Ranjan Anantharaman, Alan Edelman, ... , Avik Pal, ... , Elliot Saba, & Viral B. Shah — *2021*

International Modelica Conference

TorchGAN: A Flexible Framework for GAN Training and Evaluation

Avik Pal, & Aniket Das — *2021*

Journal of Open Source Software (JOSS)

RayTracer.jl: A Differentiable Renderer that supports Parameter Optimization for Scene Reconstruction

Avik Pal — *2019*

Proceedings of the JuliaCon Conferences

Workshop Papers

Convergence Dynamics and Eigenvalue Analysis of B-Spline KANs

Avik Pal, & Dipankar Das — *2024*

NeurIPS Workshop on Science for Deep Learning

Efficient GPU-Accelerated Global Optimization for Inverse Problems

Utkarsh, Vaibhav K. Dixit, Julian Samaroo, Avik Pal, Alan Edelman, & Chris Rackauckas — *2024*

ICLR Workshop on AI4DifferentialEquations in Science

Humor@IITK at SemEval-2021 Task 7: Language Models for Quantifying Humor And Offensiveness

Avik Pal, Aishwarya Gupta, Bholeshwar Khurana, Lakshay Tyagi, & Ashutosh Modi — *2021*

Proceedings of the 15th International Workshop on Semantic Evaluation (SemEval)

Fashionable Modelling with Flux

Mike Innes, Elliot Saba, ... , **Avik Pal**, & Viral B. Shah *2019*

NeurIPS Workshop on Systems for Machine Learning

Preprints

NonlinearSolve. jl: High-Performance and Robust Solvers for Systems of Nonlinear Equations

Avik Pal, Flemming Holtorf, Axel Larsson, Torkel Loman, ... , Alan Edelman, & Chris Rackauckas *2024*

Under Review at ACM Transactions on Mathematical Software (TOMS)

Differentiable Programming for Differential Equations: A Review

Facundo Sapienza, Jordi Bolibar, ... , **Avik Pal**, ... , Per-Olof Persson, & Chris Rackauckas *2024*

Under Review at SIAM Review

Work Experience

Research Experience

Julia Lab, MIT, Graduate Research Assistant *Cambridge, USA*

PI(s): Dr. Alan Edelman & Dr. Chris Rackauckas *Sept. '21 - Present*

- Developing a Generalized Framework for Embedding Equality and Inequality Constraints in Neural Networks
- Working on Sparse Automatic Differentiation for fast Boundary Value Problems and Complementarity Problems
- Generalized the framework of infinitely deep discrete neural networks to the continuous domain (Continuous DEQs)
- Improved Training and Prediction Time of Deep Equilibrium Models by over 2x using Predictor-Corrector Methods

Intel Labs, Graduate Research Intern *Santa Clara, USA*

Manager: Dr. Dipankar Das *May - Aug. '24*

- Explored parameter efficient learning using Kolmogorov-Arnold Networks
- Demonstrated that MLPs significantly outperform KANs in scientific machine learning tasks
- Publication: **Convergence Dynamics and Eigenvalue Analysis of B-Spline KANs**

Google AI, Student Researcher *Mountain View, USA*

Manager(s): Dr. Andrey Zhmoginov, & Dr. Lily Hu *May - Aug. '22*

- Proposed a novel deep learning method to augment fast coarse-grained simulations to approximate slow fine-grained simulations
- Demonstrated that Black-Box Neural Simulators cannot capture stable long-term dynamics
- Developed Probabilistic Neural Simulators to capture all possible wildfire dynamics
- Code: Wildfire Simulator in JAX

University of Toronto & Vector Institute, Research Intern *Toronto, CAN*

PI: Dr. Sanja Fidler *Jan. - Dec. '20*

- Worked on Multi Agent Reinforcement Learning for Emergence of Social Driving Rules
- Developed a suite of driving environments with the intention of stimulating interest within the MARL community to solve fundamental self-driving problems
- Analyzed what choices in the definition of the Partially Observed Markov Decision Process leads to the emergence of social driving rules
- Proposed metrics for empirical analysis of emergent driving behavior
- Publication: **Emergent Road Rules In Multi-Agent Driving Environments**

Engineering Experience

Julia Computing (now JuliaHub), Engineering Simulation Intern *Remote*

Manager: Dr. Christopher Rackauckas *Jan. '21 - July. '21*

- Researching Machine Learning Models for Surrogatizing Complex Physical Models
- Developed Reservoir Computing Models to deal with Stiff Physical Systems
- Publications(s):
  - **Accelerating Stiff Pharmacology Models: Continuous-Time ESNs as Implicit ML**
  - **Composing Modeling and Simulation with Machine Learning in Julia**

Research Talks

2022 **Lux.jl: Explicit Parameterization of Neural Networks in Julia**, JuliaCon

2022 **Mixing Implicit and Explicit Deep Learning with Skip DEQs**, SciMLCon

2019 **Differentiable Rendering and its Applications in Deep Learning**, JuliaCon

Open Source Software

3920 github stars across significant open-source projects

2018	**torchgan/torchgan**, Research Framework for easy and efficient training of GANs based on Pytorch.	*1399* ★ </>
2024	**SciML/NeuralPDE.jl**, Physics-Informed Neural Networks (PINN) Solvers of (Partial) Differential Equations for Scientific Machine Learning (SciML) accelerated simulation.	*988* ★ </>
2022	**LuxDL/Lux.jl**, Elegant and Performant Scientific Machine Learning in Julia.	*498* ★ </>
2021	**SciML/SciMLSensitivity.jl**, A component of the DiffEq ecosystem for enabling sensitivity analysis for scientific machine learning (SciML). Optimize-then-discretize, discretize-then-optimize, adjoint methods, and more for ODEs, SDEs, DDEs, DAEs, etc.	*330* ★ </>
2023	**SciML/NonlinearSolve.jl**, High-performance and differentiation-enabled nonlinear solvers (Newton methods), bracketed rootfinding (bisection, Falsi), with sparsity and Newton-Krylov support.	*235* ★ </>
2018	**FluxML/NNlib.jl**, Neural Network primitives with multiple backends.	*203* ★ </>
2020	**fidler-lab/social-driving**, Design multi-agent environments and simple reward functions such that social driving behavior emerges.	*135* ★ </>
2021	**SciML/DeepEquilibriumNetworks.jl**, Implicit Layer Machine Learning via Deep Equilibrium Networks, O(1) backpropagation with accelerated convergence.	*50* ★ </>

Teaching

18337J: Parallel Computing and Scientific Machine Learning — *MIT*

Teaching Assistant — *Spring 2023*

High-Performance Computing and Scientific Machine Learning course primarily geared toward graduate students

CS633: Parallel Computing — *IIT Kanpur*

Teaching Assistant — *Spring 2021*

Parallel Computing Course for advanced undergraduates and graduate students

CS771: Introduction to Machine Learning — *IIT Kanpur*

Teaching Assistant — *Fall 2020*

Introductory Machine Learning Course designed primarily for 3^{rd}-year undergraduates and 1^{st} year graduate students

Professional Activities

'24, '25	**Internal Conference on Learning Representations (ICLR)**, Reviewer for 6 + 3 papers
'23, '24	**Neural Information Processing Systems (NeurIPS)**, Reviewer for 6 + 6 papers
'22	**International Conference on Machine Learning (ICML)**, Reviewer for 3 papers

Honors and Awards

2023	**Best Student Paper Award**, IEEE High Performance Extreme Computing Conference	*USA*
2017-20	**Academic Excellence**, Top 10% students in 3 Consecutive Academic Year	*IIT Kanpur*
2017	**Inspire Scholarship for Higher Education**, Top 1% students in 10+2 board results	*India*
2017	**National Standard Examination in Astronomy**, Qualified for Indian National Astronomy Olympiad	*India*