Manu Jayadharan, PhD

Postdoctoral Fellow, Department of Engineering Sciences & Applied Mathematics
Northwestern University
manu.jayadharan@northwestern.edu · +1 412 499 5825
github.com/mjayadharan · Google Scholar · ORCID: 0009-0007-9287-3325

Research Interests

Scientific machine learning, particularly stable and interpretable methods for data-driven model discovery and their applications across science and engineering. Inverse problems for differential equations, sparse optimization, and identifiability. Multiphysics PDEs and finite-element methods (Biot poroelasticity, Poisson–Nernst–Planck) as the methodological foundation. Hybrid mechanistic–ML modelling (neural ODEs with symbolic structure). High-performance and open-source scientific software. A working interest in bridging industrial software practice with research methodology.

Education

University of Pittsburgh, Pittsburgh, PA, USA — Aug 2016 to Aug 2021
Ph.D. in Mathematics
Advisor: Dr. Ivan Yotov
Dissertation: *Domain Decomposition and Time-Splitting Methods for the Biot System of Poroelasticity*

IISER Mohali, Mohali, India — Aug 2011 to May 2016
BS-MS Dual Degree in Mathematics
DST INSPIRE Fellow; Top rank holder, Department of Mathematics
MS Thesis: *Study of Cauchy's Basic Equations and Convex Functions*

Academic Positions

Northwestern University, Evanston, IL, USA — Sept 2023 to Present
Postdoctoral Fellow, Applied Mathematics (PI: Dr. Niall Mangan)
Affiliated with the National Institute for Theory and Mathematics in Biology (NITMB), an NSF–Simons-funded centre for mathematical biology, and the Trienens Institute for Sustainability and Energy at Northwestern.

Selected accomplishments:

- Developed numerically stable, data-driven algorithms for discovering differential and differential-algebraic equations, motivated by interdisciplinary applications in power-grid modelling, chemical engineering, and battery design.
- Identified and analysed previously overlooked ill-posedness in dictionary-based model-discovery algorithms, linking it to inverse-problem theory and proposing QR-based stabilisation fixes.
- Contributed to stabilising non-convex optimization methods for model discovery (multiple-shooting framework with guess propagation, in preparation).
- Led the design and open-source release of `dae-finder`, a model-agnostic Python package for discovering differential-algebraic equations from noisy data via sparse optimization.
- Lead developer for fast, flexible Galerkin weak-form finite-element solvers for hybrid electrochemical reactor modelling (Poisson–Nernst–Planck with stiff Butler–Volmer boundary conditions,

complex geometries) at the Trienens Institute.

- Contributed to grant proposals on fast solvers for multiphysics PDEs and on data-driven PDE discovery; involved in periodic research reporting to institute and grant stakeholders.

Industry Experience

Citigroup Inc., New York, NY, USA May 2021 to Aug 2023
Quantitative Analyst, AVP, Global Credit Quantitative Analysis (LATAM EM Desk)
FINRA-licensed; production C++ pricing libraries; risk metrics and model validation.

- Contributed to large-scale quantitative libraries for pricing financial derivatives and computing risk and sensitivity measures used by Citi's trading desks worldwide.
- Implemented new risk metrics; supported model validation and deployment within a complex legacy production codebase.
- Built two production tools used on the EM credit desk: *Flash P&L* analysis tool and *ExtPricer*, an extended interest-rate-swap pricing engine.
- Worked closely with traders and risk managers, gaining practical exposure to financial modelling and the application of models to real-world systems. The asset-agnostic design of Citi's pricing libraries directly informed the model-agnostic architecture of my later open-source package `dae-finder`.

Publications

Refereed Journal Articles, Published / Accepted

1. **M. Jayadharan**, N. M. Mangan, et al., "SODAs: Sparse Optimization for Discovery of Differential-Algebraic Systems from Data," *Proc. Royal Society A*, 2026. DOI: 10.1098/rspa.2025.0201.
2. **M. Jayadharan**, I. Yotov, "Multiscale mortar mixed finite element methods for the Biot system of poroelasticity," *Computer Methods in Applied Mechanics and Engineering*, Vol. 435, Art. 117597, 2025.
3. **M. Jayadharan**, M. Kern, M. Vohralík, I. Yotov, "A space-time multiscale mortar mixed finite element method for parabolic equations," *SIAM Journal on Numerical Analysis*, 2023.
4. **M. Jayadharan**, E. Khattatov, I. Yotov, "Domain decomposition and partitioning methods for mixed finite element discretizations of the Biot system of poroelasticity," *Computational Geosciences*, 25, 1919–1938, 2021.

Under review / preprint

5. Y. Feng, N. M. Mangan, **M. Jayadharan**†, "Ill-conditioning in dictionary-based dynamic-equation learning: A systems biology case study," arXiv:2603.11330, 2026. (Under review, *SIAM J. Life Sciences.*)

In preparation

6. H. Chen, N. M. Mangan, **M. Jayadharan**†, "Improving Extrapolation in Neural ODEs via Monomial Augmentation and Symbolic Structure Recovery," 2026.
7. **M. Jayadharan**, N. M. Mangan, "Stabilizing Sparse Model Identification through Truly Orthogonal Candidate Libraries," 2026.

8. **M. Jayadharan**, N. M. Mangan, "A Multi-Shooting Framework for Sparse Model Discovery with Guess Propagation," 2026.

9. M. Gumman, **M. Jayadharan**, I. Yotov, "Domain decomposition methods for the Stokes–Biot model of fluid–poroelastic structure interaction," 2026.

† *corresponding / senior author. Senior-author papers (5, 6) reflect an independent research direction developed at Northwestern around stability and structural recovery in data-driven equation learning.*

Research in Progress

- **Agentic AI for Scientific Computing** (active 2025–present). Building protocols, validation frameworks, and reusable agentic skill sets for the use of frontier AI agents in scientific computing, including numerical solvers for stiff nonlinear ODEs / PDEs, parameter estimation, and HPC orchestration. Anchor application: a coupled Poisson–Nernst–Planck inverse problem with downstream applications in chemical engineering and battery materials. Collaborative with members of the Center for Optimization and Statistical Learning at Northwestern (incl. discussions with Jorge Nocedal's group). Initial grant funding secured. First graduate course offering, *Agentic AI for Scientific Computing*, at Northwestern Applied Math, Fall 2026.

Open-Source Scientific Software

- **DAE-FINDER** (`dae-finder` on PyPI). Designed and led the open-source release of a model-agnostic Python package for discovering differential-algebraic equations from noisy data via sparse optimization. Supports any algorithm exposing a `.fit()`/`.score()` interface.

- **FluidLearn**. Physics-informed neural networks for multiphysics PDEs; supervised PINN framework in Python (TensorFlow/Keras).

- **SpaceTimeDD**. Parabolic-PDE solver via space-time domain decomposition (C++).

- **BiotDDSolver**. MPI-based domain-decomposition simulator for Biot poroelasticity.

- GitHub: github.com/mjayadharan.

Invited Talks

- *From Data to Differential Equations*, Indian Institute of Space Science and Technology (IIST), August 2025. Host: Dr. Deepak Mishra.

- *SODAs for Discovering Differential-Algebraic Equations*, SIAM Annual Meeting AN25, July 2025.

- *On discovery of differential-algebraic equations*, SIAM Conf. on Mathematics in Data Science, October 2024.

Conference Presentations and Service

- *On numerical methods for discovering differential equations*, SIAM Annual Meeting AN24, July 2024.

- Organizer, Minisymposium on *Numerical methods for sparse optimization*, SIAM AN24.

- *Domain decomposition and partitioning methods for mixed finite element discretizations of the Biot system of poroelasticity*, SIAM Conf. on Mathematical and Computational Issues in the

Geosciences, Milan, June 2021.

- *Discretization techniques for the Biot system of poroelasticity*, FE Circus, Blacksburg, VA, November 2019.

Teaching Experience

- **Northwestern University** Fall 2026
  Instructor (graduate), *Agentic AI for Scientific Computing* (Applied Mathematics; new course developed by the candidate; project-based with funded frontier-model access for enrolled students).

- **Northwestern University** Fall 2023
  Instructor, Engineering Analysis 4: Differential Equations.

- **University of Pittsburgh** Summer 2017
  Instructor, MATH 290: Introduction to Ordinary Differential Equations and Applications.

- **University of Pittsburgh** 2016 to 2021
  Teaching Fellow / Teaching Assistant: Calculus I–III, Business Calculus, Ordinary Differential Equations.

Mentoring

Mentored six undergraduate and two graduate / master's students across Northwestern University, UC Berkeley, Carnegie Mellon University, IIST, and the University of Pittsburgh. Several mentees are co-authors with me on papers in preparation, including the senior-authored manuscript on monomial-augmented neural ODEs (Chen, Mangan, **M. Jayadharan**[†], 2026), where the candidate's mentee is first author and the candidate set the research direction.

Awards, Fellowships, and Honors

- Provost's Dissertation Completion Fellowship, U. Pittsburgh, 2021.
- Graduate Student Researcher (NSF support), U. Pittsburgh, 2018–2020.
- Arts & Sciences Graduate Fellowship, U. Pittsburgh, 2017.
- UGC–CSIR NET and IIT–GATE in Mathematics, 2016.
- Summer Research Intern Fellowship, NNMCB, IISc Bengaluru, 2015.
- Merit Certificate for Academic Excellence in Mathematics, IISER Mohali, 2014.
- DST INSPIRE Scholarship, Government of India, 2011–2016.
- Top 0.1% merit certificate in Physics, national CBSE exam, 2011.

Professional Service

- NITMB-affiliated researcher (current).
- Vice President, Association for Women in Mathematics (Pitt Chapter), 2020–2021.
- Officer, Graduate Student Organization, U. Pittsburgh, 2018–2020.
- Organizer, Minisymposium on Numerical Methods for Sparse Optimization, SIAM AN24.

Technical Skills

Languages: Python, C++, Julia, MATLAB, Fortran, SQL.

Numerical / SciML: FEM, sparse optimization, neural ODEs, SINDy / DAE-FINDER family, PINNs, multiple shooting, QR orthogonalization, weak-form / variational methods.

HPC: MPI, deal.II, FEniCS, FreeFem++, Slurm.

ML / Data: NumPy, SciPy, SymPy, scikit-learn, TensorFlow / Keras, Pyro.

Application domains: Scientific machine learning, multiphysics PDEs, electrochemistry, systems biology, power-grid modelling, quantitative finance.

References

- **Dr. Niall Mangan**, Assistant Professor, Engineering Sciences & Applied Mathematics, Northwestern University. niall.mangan@northwestern.edu. *(Postdoc advisor.)*
- **Dr. Ivan Yotov**, Professor, Department of Mathematics, University of Pittsburgh. yotov@pitt.edu. *(PhD advisor.)*
- **Dr. Deepak Mishra**, Professor, Department of Avionics, IIST. deepak.mishra@iist.ac.in. *(Long-term research mentor and current IIST collaborator; host of the August 2025 invited talk.)*