Prashant K. Jha

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Summary

My research uses mechanics, applied mathematics, and computational science to understand and represent the complex behavior of materials, e.g., multiphysics effects in materials, material damage, crack propagation, and high-fidelity simulation of granular media involving arbitrarily shaped particles and particle breakage. My interests include the mechanics of smart materials, focusing on functional soft and granular materials.

Positions

Research Associate
Dec 2020 – present
Oden Institute for Computational Engineering and Sciences
The University of Texas at Austin, Austin, TX 78712, USA
PI: Prof. J. Tinsley Oden

▷ Past Positions

Adjunct Faculty
Aug 2021 – Dec 2021
Department of Aerospace Engineering and Engineering Mechanics
The University of Texas at Austin, Austin, TX 78712, USA

Adjunct Faculty
Aug 2021 – Dec 2021
Department of Biomedical Engineering
The University of Texas at Austin, Austin, TX 78712, USA

Peter O'Donnell Postdoctoral Fellow
Aug 2019 – Nov 2020
Oden Institute for Computational Engineering and Sciences
The University of Texas at Austin, Austin, TX 78712, USA
PI: Prof. J. Tinsley Oden

Postdoctoral Fellow
Oct 2016 – Jul 2019
Department of Mathematics
Louisiana State University, Baton Rouge, LA 70803, USA
PI: Prof. Robert Lipton

Education

Ph.D.
2012 – 2016
Civil and Environmental Engineering
Carnegie Mellon University, Pittsburgh, PA 15213, USA
Adviser: Prof. Kaushik Dayal
Thesis: Coarse graining of electric field interactions with materials

M.E.
2010 – 2012
Mechanical Engineering
Indian Institute of Science, Bengaluru, KA 560012, India
Adviser: Prof. Chandrashekhar S. Jog
Thesis: A monolithic strategy for fluid-structure interaction in compressible flow

B.E.
2006 – 2010
Mechanical Engineering
Govt. Engineering College, Raipur, CG 492001, India

Teaching Experiences

COE 311K
Fall 2021
Engineering Computation (Department of Aerospace Engineering and Engineering Mechanics)
The University of Texas at Austin, Austin, TX 78712, USA

BME 313L
Fall 2021
Numerical Methods in Biomedical Engineering (Department of Biomedical Engineering)
The University of Texas at Austin, Austin, TX 78712, USA

Journal Responsibilities

▷ Journal Editing

Associate Editor — Journal of Peridynamics and Nonlocal Modeling (JPER) (link)
Topic Editor — Journal of Open Source Software (JOSS) (link)
Editorial Board Member — Scientific Reports (link)

▷ Journal Reviews

CMAME (15+ reviews), JMPS, SINUM, M3AS, MMS, JALCOM, IJMST, BMJ Open, Mathematical Reviews (AMS), PHYSA

Grants

1. **MDACC-Oden-TACC** — A mechanistic tumor growth model for HP MRI ($50k)
   Sep 2020 – Mar 2022 — PI: Fuentes (MD Anderson Cancer Center), co-PI: **Jha**

Expertise

▷ Skills

Bayesian Parameter Estimation; Continuum Mechanics; Finite Element, Finite Difference, and Meshfree Methods; Fracture Mechanics; Machine Learning; Mechanics of Granular Media; Multiphysics and Multiscale Modeling of Materials; Open-Source Software Development; Peridynamics; Scientific Computing; Uncertainty Quantification

▷ Programming Languages and Tools

C and C++; MATLAB and OCTAVE; Python; Shell; Git; Docker

Major Projects (* – Ongoing, ** – Completed)

- *__Neural Networks to accelerate scientific computing__ (at UT Austin)
  - Goal-oriented *a-posteriori* estimates of modeling error as an aid for calibration of high-fidelity models JhaOden-JCP-2022;
  - Enhancing the applications of neural operators to Bayesian inverse problems by computing correction to neural operator predictions CaoRoseberryJhaEtAl-JCP-2022;
  - Significant improvement in accuracy using our correction scheme for inference of diffusivity field in nonlinear diffusion model and Young's modulus field in hyperelastic material deformation;
  - Developed an approach to improve the accuracy and reliability of neural operator surrogates of nonlinear BVPs by proposing the so-called corrector operator JhaOden-arXiv-2023;
  - Topology optimization of the diffusivity field in a nonlinear diffusion model highlights the limitations of neural operators and a significant increase in accuracy when using the corrector approach JhaOden-arXiv-2023.
- *__Computational modeling, analysis, and design of functional materials__ (at UT Austin)
  - Modeling the effect of small-scale material conditions on effective material properties using homogenization and multiscale techniques (prior work - JhaEtAl-JAM-2022, JhaBreitzmanDayal-ARMA-2023);
  - Parameter estimation of continuum models of magnetic/electric soft composites informed by underlying microstructure;
  - Reliable neural network approximations and reduced order models CaoRoseberryJhaEtAl-JCP-2022, JhaOden-arXiv-2023.
- *__High-fidelity mechanics model for granular media__ (at UT Austin)
  - Discrete Element Method (DEM) based models are restricted to spherical particles and can not simulate particle breakage;
  - Combined peridynamics (nonlocal theory of fracture) and DEM and proposed a novel high-fidelity model called PeriDEM that overcomes the limitations of DEM-based models JhaEtAl-JMPS-2021;
  - Open-source software available on GitHub (PeriDEM).
- *__Multiphysics modeling of tissue-scale tumor growth__ (at UT Austin)
  - Developed a 3D-1D model of tumor growth and angiogenesis, coupling the evolution of tumors with the flow in tissue and vascular network FritzJhaEtAl-Nonlin-2021, FritzJhaEtAl-CMAME-2021;
  - 1D Poiseuille flow model and Darcy's law to simulate the flow in a vascular network and tissue domain, respectively;
  - Evolution of tumors, proteins, and drugs based on continuum mixture theory and phase-field method.
- **__Relating peridynamics and classical linear elastic fracture mechanics (LEFM)__ (at UT Austin and LSU, Baton Rouge)
  - Connecting LEFM and peridynamics is of great interest for the validation and broader integration of peridynamics;
  - We showed that peridynamics satisfies the LEFM energy relation JhaLipton-IJFrac-2021, LiptonJha-Nonlin-2021;
  - In the absence of fracture, peridynamics approximates elastodynamics JhaLipton-IJNME-2018;
  - Obtained a CFL-like stability condition for an explicit time discretization of peridynamics JhaLipton-IJNME-2018.
- **__Numerical method and analysis of peridynamics theory of fracture in solids__ (at LSU, Baton Rouge)
  - Implemented and studied numerical methods such as finite difference and finite element for peridynamics JhaLipton-SINUM-2018, JhaLipton-DCDSB-2021, JhaLipton-CMAME-2019;
  - Showed that the numerical solution converges to the exact solution as expected (an important contribution as such results were not clearly established before our work).
- **__Multiscale modeling of electrical interaction in ionic solids__ (at CMU, Pittsburgh)
  - Coulombic interactions are long-ranged, and it is challenging to integrate them with multiscale (e.g., Quasicontinuum) methods;
  - Obtained a continuum limit approximation of Coulombic (electrostatic) interaction and utilized the limiting energy to develop a QC method with electrostatic interaction JhaEtAl-JAM-2022, JhaBreitzmanDayal-ARMA-2023.
- **__Discrete-to-continuum limit of electrostatic interaction in nanostructures__ (at CMU, Pittsburgh)
  - Performed a rigorous derivation of continuum limit of electrostatic interaction in nanostructures with rotational and translational symmetries JhaBreitzmanDayal-ARMA-2023;
  - Unlike in the case of 3D crystal structures, the limiting electrostatic energy in nanostructures is local;
  - The limiting energy includes contributions from both the tangential and normal components of the dipole moment field; tangential components not present in the limiting energy obtained through dimensional reduction techniques.
- **__Monolithic fluid-structure interaction (FSI) formulation__ (at IISc, Bangalore)
  - Developed a monolithic arbitrary Lagrangian-Eulerian (ALE) formulation for FSI problems;
  - Compressible fluid and nonlinear solid undergoing large deformation;
  - Mapped the Navier-Stokes equations for compressible fluid to the reference configuration;
  - Developed energy-conserving time and finite element spatial discretization of nonlinear coupled fluid-solid equations.

PUBLICATIONS [GOOGLE SCHOLAR]

▷ PUBLISHED

1. P. K. **Jha** and R. Lipton, "Numerical analysis of nonlocal fracture models in holder space," SIAM Journal on Numerical Analysis, vol. 56, no. 2, pp. 906–941, 2018.
2. P. K. **Jha** and R. Lipton, "Numerical convergence of nonlinear nonlocal continuum models to local elastodynamics," International Journal for Numerical Methods in Engineering, vol. 114, no. 13, pp. 1389–1410, 2018.
3. R. Lipton, E. Said, and P. K. **Jha**, "Free damage propagation with memory," Journal of Elasticity, vol. 133, no. 2, pp. 129–153, 2018.
4. R. P. Lipton, R. B. Lehoucq, and P. K. **Jha**, "Complex fracture nucleation and evolution with nonlocal elastodynamics," Journal of Peridynamics and Nonlocal Modeling, vol. 1, no. 2, pp. 122–130, 2019.
5. P. K. **Jha** and R. Lipton, "Numerical convergence of finite difference approximations for state based peridynamic fracture models," Computer Methods in Applied Mechanics and Engineering, vol. 351, pp. 184–225, 2019.
6. P. Diehl, P. K. **Jha**, H. Kaiser, R. Lipton, and M. Lévesque, "An asynchronous and task-based implementation of peridynamics utilizing hpx—the c++ standard library for parallelism and concurrency," SN Applied Sciences, vol. 2, no. 12, pp. 1–21, 2020.
7. P. K. **Jha** and R. Lipton, "Finite element convergence for state-based peridynamic fracture models," Communications on Applied Mathematics and Computation, vol. 2, no. 1, pp. 93–128, 2020.
8. P. K. **Jha** and R. P. Lipton, "Kinetic relations and local energy balance for lefm from a nonlocal peridynamic model," International Journal of Fracture, vol. 226, no. 1, pp. 81–95, 2020.
9. P. K. **Jha**, L. Cao, and J. T. Oden, "Bayesian-based predictions of covid-19 evolution in texas using multispecies mixture-theoretic continuum models," Computational Mechanics, vol. 66, no. 5, pp. 1055–1068, 2020.
10. P. K. **Jha**, P. S. Desai, D. Bhattacharya, and R. Lipton, "Peridynamics-based discrete element method (peridem) model of granular systems involving breakage of arbitrarily shaped particles," Journal of the Mechanics and Physics of Solids, vol. 151, p. 104376, 2021.
11. R. P. Lipton and P. K. **Jha**, "Nonlocal elastodynamics and fracture," Nonlinear Differ. Equ. Appl. 28, vol. 23, 2021.
12. P. K. **Jha** and R. Lipton, "Finite element approximation of nonlocal dynamic fracture models," Discrete & Continuous Dynamical Systems-B, vol. 26, no. 3, p. 1675, 2021.
13. M. Fritz, P. K. **Jha**, T. Köppl, J. T. Oden, and B. Wohlmuth, "Analysis of a new multispecies tumor growth model coupling 3d phase-fields with a 1d vascular network," Nonlinear Analysis: Real World Applications, vol. 61, p. 103331, 2021.
14. M. Fritz, P. K. **Jha**, T. Köppl, J. T. Oden, A. Wagner, and B. Wohlmuth, "Modeling and simulation of vascular tumors embedded in evolving capillary networks," Computer Methods in Applied Mechanics and Engineering, vol. 384, p. 113975, 2021.
15. D. A. Hormuth, C. M. Phillips, C. Wu, E. A. B. F. Lima, G. Lorenzo, P. K. **Jha**, A. M. Jarrett, J. T. Oden, and T. E. Yankeelov, "Biologically-based mathematical modeling of tumor vasculature and angiogenesis via time-resolved imaging data," Cancers, vol. 13, no. 12, 2021.
16. P. Gadikar, P. Diehl, and P. K. **Jha**, "Load balancing for distributed nonlocal models within asynchronous many-task systems," in 2021 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW), (Los Alamitos, CA, USA), pp. 669–678, IEEE Computer Society, jun 2021.
17. P. K. **Jha** and P. Diehl, "Nlmech: Implementation of finite difference/meshfree discretization of nonlocal fracture models," Journal of Open Source Software, vol. 6, no. 65, p. 3020, 2021.
18. P. K. **Jha** and J. T. Oden, "Goal-oriented a-posteriori estimation of model error as an aid to parameter estimation," Journal of Computational Physics, vol. 470, p. 111575, 2022.
19. P. K. **Jha**, J. Marshall, J. Knap, and K. Dayal, "Atomic-to-continuum multiscale modeling of defects in crystals with nonlocal electrostatic interactions," Journal of Applied Mechanics, vol. 90, 11 2022.
20. P. K. **Jha**, T. Breitzman, and K. Dayal, "Discrete-to-Continuum Limits of Long-Range Electrical Interactions in Nanostructures," Archive for Rational Mechanics and Analysis, vol. 247, no. 2, p. 29, 2023.
21. L. Cao, T. O'Leary-Roseberry, P. K. **Jha**, J. T. Oden, and O. Ghattas, "Residual-based error correction for neural operator accelerated infinite-dimensional bayesian inverse problems," Journal of Computational Physics, p. 112104, 2023.

▷ UNDER REVIEW

22. P. K. **Jha**, C. Walker, D. Mitchell, J. T. Oden, D. Schellingerhout, J. A. Bankson, and D. T. Fuentes, "Mutual-information based optimal experimental design for hyperpolarized 13c-pyruvate mri," Submitted for review. Preprint: https://arxiv.org/abs/2206.12509, June 2022.
23. P. K. **Jha** and J. T. Oden, "Corrector operator to enhance accuracy and reliability of neural operator surrogates of nonlinear variational boundary-value problems," arXiv preprint arXiv:2306.12047, 2023.

▷ BOOK CHAPTERS AND REPORTS

24. P. K. **Jha** and R. Lipton, Well-Posed Nonlinear Nonlocal Fracture Models Associated with Double-Well Potentials, pp. 1417–1456. Cham: Springer International Publishing, 2019.

25. P. K. **Jha** and R. Lipton, Finite Differences and Finite Elements in Nonlocal Fracture Modeling: A Priori Convergence Rates, pp. 1457–1494. Cham: Springer International Publishing, 2019.
26. R. Lipton, E. Said, and P. K. **Jha**, Dynamic Brittle Fracture from Nonlocal Double-Well Potentials: A State-Based Model, pp. 1265–1291. Cham: Springer International Publishing, 2019.
27. R. Lipton, E. Said, and P. K. **Jha**, Dynamic Damage Propagation with Memory: A State-Based Model, pp. 1495–1523. Cham: Springer International Publishing, 2019.

Professional Activities

▷ Conference Organization

- With colleagues, organized (as the main organizer) a USACM thematic conference on computational oncology. Jan 2022. Website.
- Co-organizing a minisymposium on "Integrating Machine Learning and numerical methods to accelerate engineering design" at 2nd IACM MMLDE-CSET. Sep 2023.
- Co-organizing a minisymposium M403 on "Uncertainty Quantification for Learning and Data-Driven Predictive Modeling of Complex Systems" at the 17th U. S. National Congress on Computational Mechanics. Jul 2023.
- Co-organized a minisymposium M19 on "Nonlocal models in mathematics and computation" at the SIAM TX-LA 3rd Annual Meeting. Oct 2020.

▷ Mentoring

- Co-mentored a student working on the Google Summer of Code 2020 summer project. Related github repository. Summer 2020.

▷ Open-sourced Software

PeriDEM. (Jha et al., JMPS 2021); **NLMech.** (Jha & Diehl, JOSS 2021); **Angiogenesis3D1D.** (Fritz et al., CMAME 2021)

Awards and Achievements

1.	GATE exam (May 2010)	All India rank 31 (957/1000 score) in GATE-2010 exam
2.	TA Award (May 2013)	Best TA for finite-element method course, Carnegie Mellon University
3.	Fellowship (Aug 2019)	Peter O'Donnell Postdoctoral Fellowship, The University of Texas at Austin

Travel

1.	**Visit**	Institute for Mathematics and its Applications
	Feb 2017 – May 2017	*University of Minnesota Twin Cities, Minneapolis, MN 55455, USA*
2.	**Workshop**	Fracture as an Emergent Phenomenon
	7 Jan – 12 Jan 2024	*Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany*

Key Talks

1. Seminar: *Coarse graining of electric field interactions with materials.* Mechanical Engineering Seminar, Indian Institute of Science, Bengaluru, India. Aug 2016.
2. Seminar: *Coarse graining of electric field interactions with materials.* AEM Mechanics Research Seminar, University of Minnesota Twin Cities, Minneapolis, USA. Mar 2017.
3. Seminar: *Numerical analysis of nonlocal fracture models.* IMA Postdoctoral Seminar, University of Minnesota Twin Cities, Minneapolis, USA. Apr 2017.
4. Conference: *Numerical analysis of nonlocal fracture models.* USNCCM14, Montreal, Canada. Jul 2017.
5. Conference: *Free damage propagation with memory.* 13th World Congress in Computational Mechanics, New York, USA. Jul 2018.
6. Conference: *Convergence results for finite element and finite difference approximation of nonlocal fracture.* ICIAM 2019, Valencia, Spain. Presented by Prof. R. Lipton. Jul 2019.
7. Conference: *Numerical fracture experiments using nonlinear nonlocal models.* US National Congress on Computational Mechanics USNCCM15, Austin, USA. Jul 2019.
8. Seminar: *Application of peridynamics to fracture in solids and granular media.* Special Mechanics Seminar, University of Houston, Houston, USA. Oct 2020.
9. Seminar: *Application of peridynamics to fracture in solids and granular media.* MAE Seminar Series, University at Buffalo, Buffalo, USA. Oct 2020.
10. Seminar: *Modeling failure in solids and tissue-scale tumour growth via high-fidelity computational methodologies.* Department Seminar, Department of Computational and Data Science, Indian Institute of Science, Bengaluru, India. May 2021.
11. Conference: *Analysis and Application of Peridynamics to Fracture in Solids and Granular Media.* EMI 2021, USA. May 2021.
12. Seminar: *High-fidelity mechanistic modeling of tumor growth at the tissue scale.* Babuška Forum, Oden Institute, The University of Texas at Austin, Austin, USA. Sep 2021.
13. Conference: *Goal-oriented a-posteriori estimation of model error as an aid to parameter estimation.* USNCCM 17, Albuquerque, USA. July 2023.

Key References

Prof. Kaushik Dayal	*Carnegie Mellon University*; E: Kaushik.Dayal@cmu.edu; P: 1-412-268-2949; W: Homepage
Prof. Robert Lipton	*Louisiana State University*; E: lipton@lsu.edu; P: 1-225-578-1569; W: Homepage
Prof. J. Tinsley Oden	*The University of Texas at Austin*; E: oden@oden.utexas.edu; P: 1-512-471-3312; W: Homepage