Bhavesh Shrimali

Contact Information

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Research Interests

Computational Mechanics; Applied Mathematics; Deep Neural Operators; Deep Generative and Dynamical Models; High Performance Computing; Finite Elements

Education

University of Illinois Urbana-Champaign **4.0/4.0**

- Ph.D., Computational Mechanics (CEE), 2017-present
  Advisor: Prof. Oscar Lopez-Pamies
  Minor: Computational Science and Engineering (CSE), 2017-present
- M.S., Computer Science 2021-present **4.0/4.0**
- M.S., Civil Engineering (minor: CSE), 2015-17 **4.0/4.0**

Indian Institute of Technology (IIT) Guwahati **9.22/10.00**

- B.Tech, Civil Engineering, 2011-15
- *Ranked* 1^{st} *in the department*

Publications

[5] **Bhavesh Shrimali**, Kamalendu Ghosh, and Oscar Lopez-Pamies. The nonlinear viscoelastic response of suspensions of vacuous bubbles in rubber: I—gaussian rubber with constant viscosity. *Journal of Elasticity*, 2021 [**pdf**]

[4] Kamalendu Ghosh, **Bhavesh Shrimali**, Aditya Kumar, and Oscar Lopez-Pamies. The nonlinear viscoelastic response of suspensions of rigid inclusions in rubber: I—gaussian rubber with constant viscosity. *Journal of the Mechanics and Physics of Solids*, page 104544, 2021 [**pdf**]

[3] **Bhavesh Shrimali**, Matteo Pezzulla, Samuel Poincloux, Pedro Reis, and Oscar Lopez-Pamies. The remarkable bending properties of perforated plates. *Journal of the Mechanics and Physics of Solids*, 154, 2021 [**pdf**]

[2] **Bhavesh Shrimali**, William J. Parnell, and Oscar Lopez-Pamies. A simple explicit model constructed from a homogenization solution for the large-strain mechanical response of elastomeric syntactic foams. *International Journal of Nonlinear Mechanics*, 2020 [**pdf**]

[1] **Bhavesh Shrimali** and Victor Lefèvre and Oscar Lopez-Pamies. A simple explicit homogenization solution for the macroscopic elastic response of isotropic porous elastomers. *Journal of the Mechanics and Physics of Solids*, 122:364 – 380, 2019 [**pdf**]

Technical Skills

Languages: Python, C++, Julia, Fortran

Finite Element Libraries: FEniCS, Firedrake, scikit-FEM, NGSolve, GridAP.jl, Ferrite.jl

Commercial FE Packages: ABAQUS, COMSOL

Distributed Computing: MPI, OpenMP, CUDA

Miscellaneous: Bash, Git, pybind11, Gmsh, Netgen

DL frameworks: PyTorch, JAX, Flux.jl

Teaching

- CEE 598: Constitutive Modeling
- CEE 471: Structural Mechanics [Excellent TA.]
- CSE 551: Finite Element Methods
- CS 357: Numerical Methods

Awards & Achievements

- **Travel Fellowship**: Awarded to present my research at **WCCM-ECCOMAS, 2020** [*'20*]
- **Outstanding TA**: Ranked as an excellent TA for Structural Mechanics [*'17, '19*]
- **Institute silver medal**, IIT Guwahati: Ranked first in the graduating class [*'15*]
- **DAAD-WISE fellowship**: Awarded to approximately 150 Indian undergraduates to pursue a summer research internship in Germany [*'14*]
- **IET India Scholarship**: Awarded to about 170 students from select universities in India based on a nationwide scholastic exam [*'14*]

- **OPJEMS**: Among the top 50 students selected from all over India for the scholarship ['*13*]
- **Dhrishti 2012**: Among the *top 5* teams who proposed novel unconventional energy solutions for meeting India's future energy needs ['*12*]
- **Institute Merit Scholarship**, IIT Guwahati: Awarded annually to the top ranked student in each department based on the year round academic performance ['*12*-'*15*]
- **Indian National Olympiads**: Selected for the national level rounds in Mathematics, Physics and Astronomy ['*11*]
- **KVPY Fellow**: Ranked among 209 students from all over the country ['*10*]
- **NTSE Scholar**: Secured an All India Rank (AIR) of 324/1000 ['*07*]

Computational Projects

Fracture in Viscoelastic Solids *2021-*

I am developing a mathematical formulation and corresponding numerical implementation (in dolfinx) to simulate fracture in elastomers. The description of fracture is based on the diffused phase-field approach, and the viscoelasticity is described using the two-potential framework. The system of equations arising from the FE discretization are solved using PETSc's linear and nonlinear solvers.

Solving Nonlinear PDEs using Deep Learning *2021-*

The objective is to directly learn nonlinear operators (mappings) arising in coupled nonlinear PDEs, specifically those arising in solid mechanics. The broad idea is to leverage and improve upon novel DL architectures such as Graph Kernel Networks, Fourier Neural Operators, DeepONet to learn internal constraints in such solids

Homogenization of Gaussian rubber with constant viscosity *2020-2021*

We proposed approximate solutions that describe the overall finite-viscoelastic behavior of porous elastomers wherein the matrix is Neo-Hookean and has a constant viscosity. We implemented a higher order conforming discretization as an Abaqus user subroutine (in Fortran). I also implemented generation of periodic random microstructures (in python) and its corresponding FE mesh (in python) using Netgen/NGSPy.

Numerical Homogenization of Multiscale PDEs *2016-2019*

Guide: Oscar Lopez-Pamies, (CEE) UIUC [**code**, **paper**]

Implemented parallel, stable and robust finite element (FE) discretizations in **FEniCS** to solve nonlinear variational problems on periodic meshes. Recent work involved coupling these with high-order *time*-explicit-integration algorithms to solve PDEs in nonlinear viscoelasticity. The numerical schemes were demonstrated to be optimally convergent (in time and space).

Conforming/Non-Conforming Finite Elements for Biharmonic Problems *2018-2020*

Guide: Oscar Lopez-Pamies, (CEE) UIUC [**paper**]

The framework was implemented in **FEniCS**. A future goal is to implement it in **scikit-fem** and accelerate the FE code on GPUs via the distributed computing features offered by NVIDIA's **Legate-NumPy**

Multigrid Finite Elements in Hyperelasticity *2018*

Guide: Luke Olson, (CS) UIUC [**report**]

Implemented a vectorized FE code (in pure NumPy) with multigrid preconditioners/multilevel solvers from **PyAMG** to simulate the response of hyperelastic materials over a large range of physical properties. This work was done in collaboration with Tejaswin Parthasarathy. We demonstrated that the multilevel solvers in PyAMG when tuned appropriately, can compete with their direct counterparts, e.g. SUPERLU in `scipy.sparse.linalg.spsolve`, in both speed and accuracy, even for small problems ($N \sim$10k dofs)

Undergraduate Research Internships

Technische Universität Braunschweig [*Summer '14*]
Advisor: Prof. Dr. Klaus Thiele
Solved an inverse problem to determine the optimal location of a damper to suppress the higher order modes (eigenvalues) of a cable-stayed bridge Nijmegen bridge in Netherlands.

Hong Kong University of Science and Technology [*Summer '13*]
Advisor: Prof. Christopher K Y Leung I worked on tuning the proportion of elastomeric and steel fibres in high performance concrete to enhance the post peak softening response. I also worked on validating a FE analysis of a notched beam subject to 3-point bending with the in situ experiments.

Courses

- Machine Learning, Fast Algorithms and Integral Equations, Multigrid Methods,
- Deep Generative Models, Nonlinear Finite Elements, Generalized Finite Element Method
- Numerical methods for PDEs, Computational Inelasticity, Constitutive Modeling