RAJESH NAKKA, PhD

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PhD with expertise in computational mechanics, software development and deep learning. Skilled in Finite Element Analysis (FEA), Python, Julia, Git, and growing interest in high performance parallel computing, with a strong focus on applying academic research to practical industrial R & D solutions.

Education

PhD, IISc Bengaluru, India — 2018-2023

Thesis: *Prediction of multi-physical properties of fibre-reinforced composites using deep learning*

M.Tech, IIT Bombay, India — 8.89/10.0 || 2012-2014

Thesis: *Finite element simulation of bulk wave propagation in non-linear solids*

B.Tech, JNTUH College of Engineering Hyderabad, India — 77.03/100.0 || 2008-2012

Skills

[...]: **Proficient**, (...): **Familiar**

Subject Areas	[Solid Mechanics, Finite Element Analysis, Micro-mechanics]
Finite Element Analysis tools	[gmsh, ABAQUS, FreeCAD], (ANSYS, FEniCSx, ParaView)
Coding Languages	[Julia, Python], (C/C++, Fortran)
System & Code Management	[Linux, Windows, Git, Power shell, slurm]
Deep Learning Frameworks	[PyTorch], (TensorFlow)
Documentation	[Latex, Markdown], (reStructuredText,)
Communication Languages	[English, Telugu, Hindi]

Interests

- Computational Mechanics
- Finite Element Analysis (FEA) and Simulation
- Computational Geometry
- Computational Software Development
- High-Performance Computing
- Scientific Machine Learning

Projects

Virtual Microstructure Generator for FEA of Composite Materials Julia, Python, ABAQUS || [Article]

- Developed a computationally efficient composite microstructure (RVE) generation method that can handle ***arbitrary inclusion shapes*** for **large fibre volume fractions**, using a novel ***union of n-spheres*** approach.
- Reduced the RVE generation time from ***100+ minutes to less than a second***, using ***explicitly derived gradients*** and **optimal coding practices**, compared to the literature.
- Validated the resemblance between generated & actual microstructures by statistical & micro-mechanical analysis.

Homogenisation Tool using FEA & VAM for Multi-physical Properties Evaluation Julia, ABAQUS || [Article]

- Developed an ***in-house homogenisation tool*** for determining *thermo-elastic, thermal conduction and piezo-electric* properties of composite materials, using Variational Asymptotic Method formulation and Finite Element Method.
- Reduced computational time significantly in comparison to conventional FEM approach.
- Evaluated the *influence of fibre cross-section profile* on the effective multi-physical properties, using this tool.

Finite Element Simulation of Bulk Wave Propagation in Non-Linear Solids ANSYS APDL, Matlab || -

- Solved the governing equations for bulk wave propagation in an infinitely long cylindrical rod made up of *linear* (steel) and *non-linear* (Mooney-Rivlin two parameter model) materials, and the resulting *dispersion curves* are plotted.
- Proved, theoretically, that mixing two waves with frequency ratio 3 **enhances the second harmonic amplitude by 61.8%**. This improves the damage detection accuracy by reducing the noise interference.

CNN-based Surrogate Model for Predicting Multi-physical Properties PyTorch, Julia || [Article][Repo][Data]

- Developed a conventional neural network (CNN) model that is applicable for uni-directional composites containing ***wide range of fibre volume fractions (< 75%) and fibre-matrix material systems***.
- Developed a simple ***material property encoding scheme*** to ensure that the model learns material information, in addition to the structural information from microstructure image.
- Predicted thermal conduction, thermal expansion and elastic moduli with the ***absolute percentage error less than 5%, for about 90% of the test samples***.
- Enforced ***physics-based HS bounds*** as hard-constraints to ensure physically consistent model predictions.

Experience

Research Consultant – Compressor Rotor Profile Design, City, University of London Aug'2023-Sep'2024

- Developed a generative deep learning model, WGAN-GP, capable of producing *novel and valid* rotor profiles of twin screw compressors, trained on 60000 samples synthesised in point cloud format.
- Designed & trained the generator to produce manufacturing grade smooth profiles utilising Bezier curves.
- Achieved comparable performance in displacement volume, inter lobe sealing line area and blowhole area for approximately 20% of the generated profiles, despite the model not being explicitly trained for performance.

Assistant Professor – Mechanical Engineering, Bapatla Engineering College, AP, India Jul'2015-Nov'2016

- Delivered lectures in *Mechanics of Materials* and *Design of Machine Elements* course to undergraduate students for three semesters, reaching out to more than 100 students each semester.
- Guided four students for a bachelor's project *on stress analysis of compound cylinders*, providing mentorship in literature review, problem formulation and documentation.
- Taught `ANSYS Mechanical`, covering key aspects of FEA simulations through simple & effective examples

Post Graduate Engineer Trainee, Mahindra Research Valley, M & M, Chennai, India Aug'2014-Jul'2015

- Acquired valuable insights into the industrial working culture by visiting various M & M plants involved in SUV and tractor production, familiarising with product development cycles and plant operations.
- Engaged briefly with the Occupant Safety and Engine Design departments, gaining a glimpse of virtual and practical safety simulations, engine development strategies, and their contribution to the successful product development.

Publications

J: Journal, C: Conference, U: Under Preparation, P: Patent

[**J1**] **Rajesh Nakka**, D. Harursampath, M. Pathan, and S. A. Ponnusami, "A computationally efficient approach for generating RVEs of various inclusion/fibre shapes," *Composite Structures*, vol. 291, p. 115 560, Jul. 2022. DOI: 10.1016/j.compstruct.2022.115560.

[**J2**] **Rajesh Nakka**, D. Harursampath, and S. A. Ponnusami, "A generalised deep learning-based surrogate model for homogenisation utilising material property encoding and physics-based bounds," *Scientific Reports*, vol. 13, no. 1, Jun. 2023. DOI: 10.1038/s41598-023-34823-3.

[**J3**] **Rajesh Nakka**, A. P. Kumar, D. Harursampath, and S. A. Ponnusami, "Influence of fibre cross-section profile on the multi-physical properties of uni-directional composites," *Composite Structures*, vol. 321, p. 117 321, Oct. 2023. DOI: 10.1016/j.compstruct.2023.117321.

[**J4**] P. K. Attada, **Rajesh Nakka**, D. Harursampath, and S. A. Ponnusami, "Computational evaluation of absorption characteristics of ceramic-based auxetic materials in x-band frequencyrange," *Smart Materials and Structures*, Aug. 2023. DOI: 10.1088/1361-665x/acf53d.

[**C1**] **Rajesh Nakka**, A. P. Kumar, D. Harursampath, and S. A. Ponnusami, "Multi-physical property prediction of fibre-reinforced composites using convolutional neural networks," International Conference on Composite Materials, Belfast, 2023.

[**C2**] **Rajesh Nakka**, A. Kovacevic, and S. A. Ponnusami, "Designing novel rotor profiles of twin s crew compressors using generative deep learning," International Conference on Screw Machines, Dortmund, 2024.

[**U1**] **Rajesh Nakka**, S. Patil, A. Kovacevic, and S. A. Ponnusami, *Designing novel rotor profiles of twin screw compressors using generative deep learning.*

[**U2**] M. Naveen, **Rajesh Nakka**, and B. Gurumoorthy, *Inverse design of irregular periodic porous structures with controllable physical properties using generative adversarial networks.*

Exploratory Projects

- `MakeAbaqusInputFile.jl`, a Julia package for writing ABAQUS input files directly for the homogenisation of composite materials using periodic boundary conditions. It optimises the data storage by keeping the common mesh data files in central directory. [Repo]
- `npi` – **Numpy Inspector**, a Python package written for accessing numpy files, `*.npy` & `*.npz`, at command line interface for visualisation, reading and in-place operations. [Repo]
- `clip` – Command Line Interactive Parser, a short Python package written on top of Python's in-built `argparse` and `tkinter` to provide GUI interface for supplying arguments. [Repo]
- `gbox` – Geometry Box, a Python package for visualisation & mathematical operations of simple 2D shapes. [Repo][docs]

Positions of Responsibility

- Volunteered as a ***system administrator*** for the NMCAD laboratory during my PhD, for about two years. I was responsible for smooth running of **High-Performance Computing (HPC) Rocks cluster** containing ten computing nodes and **slurm workload manager**, managing licensed software and user accounts.
- Volunteered in technical conference AERES-2023, Aerospace Research Symposium, at IISc Bengaluru as a ***core team member***. My responsibilities were to manage submissions and volunteers during the presentation sessions.
- Worked as a ***teaching assistant*** for *Machine Design*, *Mechanics of Materials*, *Engineering Mathematics* & *Flight Vehicle Structures* courses during my masters at IIT Bombay and PhD at IISc Bangalore.
- ***Founding team member*** of Abhyuday, a social body of IIT Bombay during 2013-14. I was an *events manager* and responsible for organising NGO exhibitions and invited talks.

References

Prof. Dineshkumar Harursampath
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