

Vignesh Babu Rao

PH.D. · SOLID MECHANICS AND DEEP LEARNING

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Education

M.S./Ph.D. in Mechanical Engineering

UNIVERSITY OF UTAH

Aug 2019 - Dec 2024

Salt Lake City, UT, USA

- **GPA:** 3.89/4
- **Specialization:** Solid Mechanics and Deep Learning
- **Dissertation:** Accelerating high-fidelity fracture simulations in 3D microstructures using deep learning [Link](#)
- **Relevant Coursework:** Machine Learning, Deep Learning, Probabilistic Machine Learning, Advanced Finite Element Analysis (FEA), Fracture & Fatigue, Continuum Mechanics, Composite Materials

B.E. in Mechanical Engineering

ANNA UNIVERSITY

Aug 2011 - May 2015

Chennai, India

- **GPA:** 9.01/10 (99.9th percentile, **University rank** holder)

Research Experience

University of Utah | Utah Composites Laboratory | MMM Laboratory

RESEARCH ASSISTANT AND MENTOR

Salt Lake City, UT, USA

Oct 2024 - Present

- Developed a **neural network-based active learning framework** to predict composite delamination (leveraging data from **FEA** for training) and applied a **genetic algorithm** for inverse optimization
- **Building and automating** computational tools to **simulate ply-level cracking** in fiber-reinforced composites
- **Award:** Led a team of graduate students to **first place in the ASC Simulation Challenge** (2024) by developing a **machine-learning-driven** approach for composite failure prediction

University of Utah | Multiscale Mechanics & Materials Laboratory

GRADUATE RESEARCH ASSISTANT

Salt Lake City, UT, USA

Aug 2019 - Aug 2024

- Developed an **uncertainty quantification**-informed interleaved **physics-based deep-learning framework** to accelerate fatigue crack growth predictions and reduce error propagation
- Developed a high-fidelity **finite element** framework for simulating 3D microstructurally small crack growth by integrating **crystal plasticity** constitutive model with **Abaqus**, leveraging **high-performance computing** resources
- Developed an **object-oriented Python** framework and **automated** FE simulation workflows, data extraction, pre-processing, and feature engineering for deep learning applications
- Trained deep learning architectures, including **3D CNNs, Bi-LSTMs, ConvLSTMs, and Transformers**, using **TensorFlow, Keras, and PyTorch** libraries on GPUs, and conducted **model interpretability** using **SHAP** analysis
- Achieved over **100x acceleration in fracture predictions** by combining FE simulations with machine learning
- **Award: First place** in the NIST AM Benchmark Challenge (2022) for predicting mechanical behavior of AM samples

ARCI | Advanced Nanomechanical Characterization Laboratory

SENIOR RESEARCH FELLOW

Hyderabad, India

Apr 2017 - Jun 2019

- Developed and implemented an **unsupervised machine learning**-based methodology to accurately deconvolute nanoindentation maps, which enabled **automated property extraction**, later integrated into Nanomechanics Inc.'s **data analysis** software
- Simulated thermal fatigue and oxide growth in multilayered thermal barrier coating (TBC) systems using **object-oriented finite element analysis** (OOF2) and **Abaqus subroutines**
- Performed **data analysis** of high-throughput nanoindentation tests using **MATLAB** and established **structure-property correlations** via SEM image analysis

Technical Skills

Programming	Python (TensorFlow, Keras, PyTorch, Scikit-learn libraries), C++, MATLAB, Racket, Bash
AI/ML	Neural Networks, LSTMs, 3D CNNs, Transformers, Genetic Algorithm, PINNs, LLMs (RAG)
Modeling & Simulation	Abaqus, CREO parametric, FRANC3D, DREAM.3D, Paraview
General	Linux, Git, LaTeX, MS Office
Experimental	Nanoindentation, SEM, EBSD

Professional Experience

Cognizant

PROGRAMMER ANALYST

Chennai, India

Feb 2016 - Mar 2017

- **Enhanced the functionality and user experience** of Cognizant's internal applications by implementing improvements using c# and CSS
- Provided **technical support** for two applications, using SQL to manage database records and user issue resolution

India Piston Rings

PROJECT INTERN

Chennai, India

Dec 2014 - Mar 2015

- Conducted a **feasibility study** on repurposing waste Ni-Mo powder for plasma-sprayed piston ring coatings
- Performed **mechanical testing** and microstructural analysis to **validate** that piston rings coated with 10% recycled Ni-Mo powder **met industry standards**, achieving material waste reduction while **enhancing profitability**

Relevant Course Projects

- Developed an **LSTM-based predictive model** to forecast **semiconductor wafer processing equipment failure**, leveraging a year's worth of actual production data collected from advanced process control (APC)
- **EBS** analysis of additively manufactured SS316L for generating (mis)orientation maps
- Conducted digital image correlation (**DIC**) experiments to map displacement fields near a crack tip under varying loading conditions, analyzed deformation using **Vic-2D**, and computed stress intensity factors

Publications

- **Vignesh Babu Rao**, Ashley Spear, Michael Czabaj, "A framework for simulating arbitrary 3D crack propagation in fiber-reinforced composite microstructures" (in preparation).
- **Vignesh Babu Rao**, Ashley Spear, "An Interleaved Physics-based Deep-learning Framework as a New Cycle Jumping Approach for Microstructurally Small Fatigue Crack Growth Simulations," *npj Computational Materials* (2025) (Accepted).
- **Vignesh Babu Rao**, Ashley Spear, "A Deep Learning Framework to Predict Microstructurally Small Fatigue Crack Growth in Three-dimensional Polycrystals," *Computer Methods in Applied Mechanics and Engineering* 437 (2025) 117689. [Paper Link](#)
- **Vignesh Babu Rao**, Brian Phung, Bjorn Johnsson, Ashley Spear, "Statistical Analysis of Microstructurally Small Fatigue Crack Growth in Three-dimensional Polycrystals Based on High-fidelity Numerical Simulations," *Engineering Fracture Mechanics* 307 (2024) 110282. [Paper Link](#)
- Mohsin Hasan, P. Sudharshan Phani, **B. Vignesh**, K. Satya Prasad, L. Venkatesh, "Adapting High-Speed Indentation Mapping for Investigating Microstructure-Property Correlations in Chromium Carbide-Nickel Alloy Coatings: Challenges and Solutions," *Surface and Coatings Technology* (2024) 131318. [Paper Link](#)
- **B. Vignesh**, W.C. Oliver, G. Siva Kumar, P. Sudharshan Phani, "Critical Assessment of High Speed Nanoindentation Mapping Technique and Data Deconvolution on Thermal Barrier Coatings," *Materials & Design* 181 (2019) 108084. [Paper Link](#)

Conference Presentations

- **Vignesh Babu Rao***, Ashley Spear, "Using Deep Learning to Predict Microstructurally Small Crack Behavior in Three-Dimensional Microstructures," *TMS 2024 Annual Meeting & Exhibition*, Orlando, FL, March 2024.
- **Vignesh Babu Rao***, Brian Phung, Bjorn Johnsson, Ashley Spear, "Using Deep Learning for Predicting Microstructurally Small Fatigue Crack Growth Parameters in Polycrystalline Materials," *15th International Conference on Fracture*, Atlanta, GA, June 2023.
- **Vignesh Babu Rao**, Brian Phung*, Bjorn Johnsson, Ashley Spear, "Accelerating Microstructurally Small Crack Growth Predictions in Three-Dimensional Microstructures using Deep Learning," *TMS 2023 Annual Meeting & Exhibition*, San Diego, CA, March 2023.
- **Vignesh Babu Rao***, Brian Phung, Ashley Spear, "Accelerating Microstructurally Small Crack Growth Predictions in Three-Dimensional Microstructures using Deep Learning," *MMM 10*, Baltimore, MD, October 2022.
- P. Sudharshan Phani, **B. Vignesh**, G. Siva Kumar, W.C. Oliver*, "High Speed Nanomechanical Property Mapping and Data Deconvolution," *TMS 2019 Annual Meeting & Exhibition*, San Antonio, TX, March 2019.
- **B. Vignesh***, P. Sudharshan Phani, G. Siva Kumar, "High Speed Nanomechanical Property Mapping of Thermal Barrier Coating," *Second International Structural Integrity Conference & Exhibition*, Hyderabad, July 2018.