Shreyas **Gaikwad**

Graduate Research Assistant · Computational Scientist

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Summary

I am a third year Ph.D. student at the Oden Institute for Computational Engineering and Sciences at The University of Texas at Austin. I am broadly interested in machine learning, optimization, inverse problems, uncertainty quantification, computational glaciology, and computational oceanography. I am currently working on two major projects - 1. Paleochronometry as a control problem for recovering Holocene climate variations over the Greenland Ice Sheet, 2. Designing a Deep Learning Emulator for the dynamics of sea ice within the general ocean circulation model, MITgcm. Over the course of my work, I have collaborated with researchers from MIT, Argonne National Laboratory, UC San Diego, Hokkaido University, French Institute for Research in Computer Science and Automation, and Bhabha Atomic Research Centre (BARC). I am currently also serving as the Vice President of the UT Chapter of SIAM (Society for Industrial and Applied Mathematics).

Education

The University of Texas at Austin — *Austin, TX*

Ph.D. in Computational Engineering and Sciences - CGPA: 4.0/4.0 — *August 2019 - May 2024*

The University of Texas at Austin — *Austin, TX*

MS in Computational Engineering and Sciences - CGPA: 4.0/4.0 — *August 2019 - May 2021*

Indian Institute of Technology Bombay (IIT-Bombay) — *Mumbai, India*

B.Tech in Mechanical Engineering - CGPA: 9.32/10.0, Department Rank - 4/150 — *July 2015 - May 2019*

- Graduated with a Minor degree in Computer Science and Honors in Mechanical Engineering

Experience

Graduate Research Assistantship

Paleochronometry as a control problem for recovering Holocene climate variations over the Greenland Ice Sheet — *Austin, TX*

Advisor - Patrick Heimbach, Research Group - CRIOS — *September 2020 - Present*

- Integrated the open source Automatic Differentiation tool Tapenade with the SICOPOLIS ice sheet model source code in order to generate the adjoint and tangent linear codes. The adjoint calculation of the gradient is exponentially faster than the finite differences calculation.
- Built fully automated CI pipelines on TravisCI for containerized adjoint validation using Docker and pytest
- Successfully inverted for the source term of the mass equation for a basic mountain glacier model, leveraging the adjoint method to calculate the gradient along with second order quasi-Newton methods such as BFGS and L-BFGS for optimization
- Collaborations with Argonne National Laboratory, Hokkaido University, and French Institute for Research in Computer Science and Automation

Deep Learning Emulator for the Dynamics of Sea Ice — *Austin, TX*

Advisor - Patrick Heimbach, Research Group - CRIOS — *August 2021 - Present*

- Leveraging Deep Learning to reduce the computational cost of simulating sea ice in the general ocean circulation model, MITgcm
- Collaborations with MIT, Scripps Institute of Oceanography (in UC San Diego)

Projects in HPC, Data Science and Machine Learning

Mudrock Prediction from Wireline Logs Using Machine Learning — *Austin, TX*

Advisor - Sergey Fomel, Oden Institute, UT Austin — *January 2021 - May 2021*

- Developed a program to automatically pick mudrocks from wireline logs using Machine Learning algorithms on a real dataset. XGBoost and CNN found to be the best algorithms, with about 87% test accuracy. First (known) attempt to utilize this for pore pressure prediction, an important geological application. The work can be extended to map lithology across basins.

Physics Informed Neural Networks for Mountain Glaciers — *Austin, TX*

Advisor - Rachel Ward, Oden Institute, UT Austin — *January 2021 - May 2021*

- Leveraged PyTorch, and GPUs/TPUs on Google Colab in order to train a Deep Neural Network that emulates the solution of highly non-linear and diffusive glacier model. Another aspect of the project involved inferring the parameters of a non-linear, diffusive PDE using a Neural Network given that the behavior of the PDE is known at certain points in spacetime. The diffusion makes the problem highly ill-posed.

Laplacian 2D Finite Difference (FD) solver application — *Austin, TX*

Advisor - Karl Schulz, Dept. of Women's Health, Oden Institute, UT Austin — *August 2020 - December 2020*

- Features: Solver (gauss, jacobi, PETSc), tests (bats, Travis CI, Docker), 98% code coverage (lcov), 0% memory errors (Valgrind), build (Autotools), HPC env (SLURM), Storage (HDF5), parser and logger (GRVY), code verification (MASA), version control (github), OOP (C++)

Bayesian Inference of Uncertain Model Parameters using Real Data

Austin, TX

Advisor - Robert Moser, Oden Institute, UT Austin — *January 2020 - May 2020*

- Applications included the Energy Balance Model model for climate change calibrated to surface temperature data, and stokes drag calibrated with laboratory measurement data collected at UIUC. Applied Markov Chain Monte Carlo (MCMC) methods using Python in order to efficiently sample high-dimensional parameter spaces and derive posterior distributions, thus testing the theoretical frameworks against real data.

Analysis of Parallel Computing Techniques on Generalized-α method

Mumbai, India

Advisor - Shivasubramanian Gopalakrishnan, Department of Mechanical Engineering, IIT Bombay — *January 2018 - May 2018*

- Performed a comparative analysis of numerical simulations of the popular Generalized-α method (both explicit and implicit) which is used in computational structure dynamics to model fluid structure interactions as spring mass systems using parallel computing tools like OpenMP, CUDA and MPI. Achieved upto 7x speedup using MPI and upto 5x speedup using Nvidia CUDA.

Projects in Computational Fluid Dynamics and Computational Solid Mechanics

B.Tech Thesis - CFD simulations for Boiling in Nuclear Rod Bundles using OpenFOAM

Mumbai, India

Advisor - Janani Srree Muralidharan, Department of Mechanical Engineering, IIT Bombay — *July 2018 - May 2019*

- Verified trends of Eulerian solvers against experimental results for flows over nuclear rod bundles. Applied OpenFOAM, an open-source code (C++) to the area of subcooled boiling. Trained Machine Learning models using existing data on 8 mm tubes to predict values of fluid quality for new rod bundle cases after applying suitable conversion factors, achieving 76% accuracy.
- Collaborations with Bhabha Atomic Research Centre (BARC), Mumbai, India

1D Linearized Shallow Water Equations using Finite Element Methods

Mumbai, India

Advisor - Shivasubramanian Gopalakrishnan, Department of Mechanical Engineering, IIT Bombay — *July 2018 - November 2018*

- Solved the 1D hyperbolic equations for shallow water systems using continuous and discontinuous Galerkin methods and compared results for different sets of nodes such as uniformly spaced, Chebyshev, etc. Conducted spectral analysis of linear system in order to verify convergence.

2D Navier-Stokes Solver for Incompressible Flows using Finite Volume Methods

Mumbai, India

Advisor - Atul Sharma, Department of Mechanical Engineering, IIT Bombay — *July 2017 - November 2017*

- Solved the 1D hyperbolic equations for shallow water systems using continuous and discontinuous Galerkin methods and compared results for different sets of nodes such as uniformly spaced, Chebyshev, etc. Conducted spectral analysis of linear system in order to verify convergence.

Projects in Manufacturing, Microprocessors, and Control

Bionic Handling Assistant

Mumbai, India

Advisor - Parag Tandaiya, Department of Mechanical Engineering, IIT Bombay — *July 2018 - November 2018*

- Designed a simple prototype arm based on the trunk of an elephant. Modeled the kinematic analysis of the system in spherical co-ordinates. Designed and implemented an algorithm to control the motion of the trunk using multiple arduinos simultaneously.

PID Position Control

Mumbai, India

Advisor - Shashikanth Suryanarayanan, Department of Mechanical Engineering, IIT Bombay — *January 2018 - May 2018*

- Applied PID based accurate and responsive correction to a position control function for a DC Motor attached to a gear. Fine-tuned PID control coefficients and validated trends against Simulink models.

Dependence of Friction Coefficient on Texture

Mumbai, India

Advisor - Ramesh Singh, Department of Mechanical Engineering, IIT Bombay — *July 2018 - May 2019*

- Developed CNC codes to create textures on polished stainless steel surface using SPI Laser 100 at different intensities and measured coefficient of friction using self-made apparatus. Analyzed trends for Friction Coefficient vs Energy per unit length for different combinations of textures.

Internships

ITC Limited, India's Largest FMCG Conglomerate

Kolkata, India

Advisor - Aurko Chatterjee, Manufacturing Manager (Currently Global Supply Manager at Apple) — *May 2018 - July 2018*

- Interned in the packaging section of ITC's only fully owned flour plant near Kolkata, West Bengal, India
- Manpower Reduction in Primary Packing Machines - Identified priority target areas and used 5-Why analysis to determine root causes, Reduced operator involvement by 27% through increase in no-touch times by setting up feedback systems to control dosing of flour into pouches.
- Downtime Reduction of Secondary Packing Machines - Machines worth $275,000 were dysfunctional due to high downtimes. Achieved 40% reduction in downtime frequency via PDCA-cycle based improvements. Prepared standard inventory lists to quicken response to downtimes.
- Results: Manpower reduction by 50% in the packaging section, 60% machines running with no major downtime

Publications & International Conferences

2021 — **Shreyas Gaikwad**, Sri Hari Krishna Narayanan, Laurent Hascoet, Ralf Greve, Patrick Heimbach "SICOPOLIS-AD v2: An open-source tangent-linear and adjoint modeling framework for ice-sheet simulation enabled by the AD tool Tapenade", 24th EuroAD Workshop, 2021 — *Virtual*

Skills

Languages	Python (scikit-learn, Keras, PyTorch, FENICS, numpy, autograd, Pandas), C++ (GRVY, MASA, HDF5, PETSc), FORTRAN-90
Softwares	MATLAB, Scilab, Solidworks, ANSYS, ADAM, OpenFOAM, Simulink, LaTeX, Tapenade, MITgcm, SICOPOLIS
HPC	OpenMP, MPI, CUDA, SLURM
Other Tools	Github, Docker, Shell scripting, Travis-CI, Autotools, Valgrind, HTML, CSS, Jekyll, lcov

Relevant Graduate level Coursework

Data Science	Machine Learning applications in Geophysics, Foundational Techniques in Machine Learning, Engineering Data Mining
HPC	Design and Analysis of Algorithms, Tools and Techniques in Computational Science, Numerical Methods for Differential Equations, Numerical Linear Algebra, High Performance Scientific Computing, Operating Systems
Inverse problems	Uncertainty Quantification in Computational Models, Computational & Variational Methods for Inverse Problems (observer)
Mathematics	Functional Analysis, Partial Differential Equations, Analytical Methods
Fluid Dynamics	Phys. Oceanography, Mathematical Modeling in Science and Engineering, Computational Fluid Dynamics, Galerkin Methods

Honors & Awards

Fellowships & Scholarships

2019	**Peter O'Donnell Fellow**, Awarded Fellowship worth $24,000 by the Oden Institute.	*Austin, TX*
2015	**KVPY Fellow**, Conferred by Govt. of India for demonstrating aptitude for research, Rank - 27/50,000	*Mumbai, India*
2015	**INSPIRE Scholar**, Awarded scholarship for top 1 percentile standing in class XII examinations	*Nashik, India*
2012	**Bhaskar Genius Scholar**, Top 20 rank in India among 50,000 students	*Nashik, India*
2011	**MCSE PSS Scholar**, Maharashtra State Council of Examination, secured greater than 99.9995 percentile	*Nashik, India*

Others

2020	**Ph.D. Preliminary Exam**, Passed exams in applied maths, scientific computing, and maths modeling	*Austin, TX*
2019	**Honors in Mechanical Engineering**, Awarded for completing B.Tech thesis, additional graduate coursework	*Mumbai, India*
2018	**AP Grade**, Awarded in Computer Graphics, very sparingly awarded for demonstrating exceptional insight	*Mumbai, India*
2017	**AP Grade**, Awarded in Heat Transfer, very sparingly awarded for demonstrating exceptional insight	*Mumbai, India*
2015	**INChO qualification**, Indian National Chemistry Olympiad, ranked top 1% among 30,000 students	*Mumbai, India*
2015	**IIT Bombay Undergraduate Admission**, widely regarded as the best engineering institution in India	*Mumbai, India*
2015	**JEE Advanced qualification**, Stage II entrance exam for the IITs, Ranked 509 out of 150,000 candidates	*Mumbai, India*
2015	**JEE Main qualification**, Stage I entrance exam for the IITs, Ranked 983 out of 1.5 million candidates	*Mumbai, India*
2015	**BITSAT qualification**, Entrance exam for the BITs, estimated rank top 200 among 300,000 students	*Nashik, India*

Mentorship, Leadership & Volunteer Experience

2021	**Mentor**, SIAM-UT Applied Math Mentorship Program	*Austin, TX*
2021	**Vice President**, University of Texas Chapter of SIAM	*Austin, TX*
2018	**Mentor**, Department Academic Mentorship Program, IIT Bombay	*Mumbai, India*
2018	**Mentor**, Academic Rehabilitation Program, IIT Bombay	*Mumbai, India*
2016	**Volunteer**, CURED, a pan-India initiative for diabetes (178 camps, 65,000 screenings in a day)	*Mumbai, India*
2015	**Volunteer**, Educational Outreach, National Service Scheme	*Mumbai, India*

Extracurriculars

Chess, Rated 1700 in the Rapid format and 1450 in the Bullet format on Lichess

Cricket, I follow cricket ardently and play as a bowling all-rounder

Reading, a personal collection of 100+ books across various genres such as fiction, history, political science