

Education	<b>University of Illinois at Urbana-Champaign</b> , Urbana, Illinois Ph.D., Aerospace Engineering Concentration: Computational Science and Engineering	2018 – present GPA: 3.96/4.0
	<b>University of Illinois at Urbana-Champaign</b> , Urbana, Illinois M.S., Aerospace Engineering	2016 – 2018 GPA: 4.0/4.0
	<b>Indian Institute of Technology Gandhinagar</b> , Gujarat, India B.Tech. ( <i>Honors</i> ), Mechanical Engineering	2012 – 2016 GPA: 9.24/10.0
Interests	<ul style="list-style-type: none"> <li>• Computational fluid dynamics</li> <li>• Numerical modeling</li> <li>• High performance computing</li> <li>• Deep learning</li> <li>• Reinforcement learning</li> <li>• Reduced-order modeling</li> </ul>	
Experience	<b>Graduate Research Assistant</b> Ph.D. thesis adviser: Prof. Andres Goza, UIUC, Champaign, IL	September 2018–present
	<ul style="list-style-type: none"> <li>• Computational fluid dynamics (CFD) of an aeroelastic flap for passive flow control <ul style="list-style-type: none"> <li>• Computationally modeled the multi-physics flow over an airfoil mounted with a bio-inspired aeroelastic flap for improving aerodynamic performance.</li> <li>• Performed a multi-dimensional parametric study, k-means clustering and detailed data analysis to identify features that enhanced aerodynamic lift upto 27%.</li> <li>• Collaborated with a research group at Princeton University to correlate CFD simulations with wind-tunnel experiments.</li> </ul> </li> <li>• Machine learning for state estimation and active flow control <ul style="list-style-type: none"> <li>• Developed a nonlinear state estimation approach where real-time sensor data was used to accurately predict the full-flow state using deep neural networks.</li> <li>• Currently using deep reinforcement learning for designing a closed-loop controller for active flow control of an airfoil mounted with a controllable aeroelastic flap.</li> <li>• Utilized methodologies such as proximal policy optimization, principal component analysis and multi-layer perceptrons on Pytorch.</li> </ul> </li> <li>• High performance computing and development of efficient algorithms <ul style="list-style-type: none"> <li>• Developed a scalable multi-physics (fluid-structure interaction) solver involving the Navier-Stokes and Newton’s equations using PETSC and MPI.</li> <li>• Developed an efficient algorithm that addressed a critical computational bottleneck related to the computation of a fluid-structure coupling matrix.</li> <li>• Achieved 4–10x increase in serial computational speed and ~84% parallel strong scaling efficiency.</li> </ul> </li> </ul>	
	<b>Computer Science Research Institute Summer Intern</b> Adviser: Dr. Kevin Carlberg, Sandia National Laboratories, Livermore, CA Transfer learning for guaranteeing convergence of reduced-order models (ROM)	June–August 2019
	<ul style="list-style-type: none"> <li>• Formulated an adaptive refinement strategy to enable convergence of nonlinear ROMs built using deep convolutional autoencoders on Tensorflow.</li> <li>• Developed methodologies for efficiently retraining selected weights of the autoencoder and real-time augmentation of the latent space.</li> </ul>	

**Graduate Research Assistant**

August 2016–August 2018

M.S. thesis adviser: Dr. Maciej Balajewicz, UIUC, Champaign, IL

Data-driven reduced-order modeling of fluid flows

- Identified a critical drawback of linear ROMs in accurately predicting fluid flows that are dominated by advection and strong discontinuities.
- Developed a hyper-reduced, physics-based ROM where solutions are obtained by a nonlinear transformation of a linear subspace using collected flow data.
- Achieved 300-10000x increase in computational speed while incurring only  $\sim 1\%$  error when tested on several CFD problems.

**Summer Undergraduate Research Fellow**

May–July 2015

Adviser: Prof. Austin Minnich, California Institute of Technology, Pasadena, CA

Waste heat scavenging using thermoelectric generators for aircraft applications

- Designed and fabricated a thermal-electrical prototype consisting of a thermoelectric generator, heat fin and electronics to generate electricity from waste heat.
- Powered a wireless temperature sensor from a temperature difference of  $5^\circ$  K.

**Summer Research Internship Program**

May 2014–April 2015

Adviser: Prof. Vinod Narayanan, IIT Gandhinagar, India

Stability analysis of thermal boundary layers

- Performed local stability analysis to quantify the effect of heating on viscosity and the stability characteristics of axisymmetric thermal boundary layers.

**Publications**

1. N.J. Nair and A. Goza. Fluid-structure interaction of a bio-inspired passively deployable flap for lift enhancement. *Preprint arXiv:2203.00037*, 2022. (Under review at *Physical Review Fluids*).
2. N.J. Nair and A. Goza. A strongly coupled immersed boundary method for fluid-structure interaction that mimics the efficiency of stationary body methods. *Journal of Computational Physics*, 110897, 2022.
3. N.J. Nair, Z. Flynn and A. Goza. Numerical study of multiple bio-inspired torsionally hinged flaps for passive flow control. *Fluids*, 7(2), 44, 2022.
4. N.J. Nair and A. Goza. Leveraging reduced-order models for state estimation using deep learning. *Journal of Fluid Mechanics*, 897, 2020.
5. N.J. Nair and M. Balajewicz. Transported snapshot model order reduction approach for parametric, steady-state fluid flows containing parameter-dependent shocks. *International Journal for Numerical Methods in Engineering*, 2019; 117:1234–1262.

**Conference Talks and Proceedings****Invited Talks**

1. N.J. Nair and A. Goza. Active flow control of a covert-inspired deployable flap strategy using reinforcement learning. *USNC, TAM*, 2022. (Accepted).
2. N.J. Nair and A. Goza. Effects of flap-vortex interactions on the lift of an airfoil mounted with a passively deployable flap. *DisCoVor, EPFL*, 2022. (Accepted)
3. N.J. Nair and M. Balajewicz. Transported snapshot model order reduction approach for parametric, steady-state fluid flows containing parameter dependent shocks. *SIAM CSE*, 2019.

### Contributed Talks

1. A.K. Othman, N.J. Nair, A. Sandeep, A. Goza and A.Wissa. Numerical and experimental study of a covert-inspired passively deployable flap for aerodynamic lift enhancement. *AIAA Aviation*, 2022. (Accepted)
2. N.J. Nair and A. Goza. Effects of Torsional Stiffness and Inertia on a Passively Deployable Flap for Aerodynamic Lift Enhancement. *AIAA Scitech Forum*, 2022.
3. N.J. Nair and A. Goza. Approaching the efficiency of stationary-body methods in a strongly coupled immersed boundary framework for fluid-structure interaction. *APS, Division of Fluid Dynamics*, 2021.
4. N.J. Nair and A. Goza. Numerical study of a passively deployable flap for aerodynamic flow control. *APS, Division of Fluid Dynamics*, 2020.
5. N.J. Nair and A. Goza. Integrating sensor data into reduced-order models with deep learning. *APS, Division of Fluid Dynamics*, 2019.
6. N.J. Nair and M. Balajewicz. Physics based interpolation for steady parametric partial differential equations. *APS, Division of Fluid Dynamics*, 2017.
7. N.J. Nair and U. Shah. A simple computational tool for studying acoustic waves in nonlinear medium. *ASME, IDETC*, 2017.
8. N. Jayaprasad and V. Narayanan. Effect of viscosity stratification on stability of axisymmetric boundary layer. *APS, Division of Fluid Dynamics*, 2015.

### Honors & Awards

Kuck Computational Science and Engineering Scholarship, UIUC	2022
AE Outstanding Graduate Student Fellowship, UIUC	2020
Conference Travel Grant, APS DFD	2019
SIAM Student Travel Award, SIAM CSE	2019
Conference Travel Award for Graduate Students, UIUC	2017
MSNDC Student Travel Grant, ASME IDETC	2017
Commencement award for ‘Best Performance in the core subjects of Engineering Graphics, Manufacturing and Workshop Practice’, IIT Gandhinagar	2016
Summer Undergraduate Research Fellowship, Caltech	2015
Dean’s List, IIT Gandhinagar	2013, 2014, 2015
Merit cum Means Scholarship, IIT Gandhinagar	2012, 2013, 2014
Winner of Ricoh Printer Design Challenge, IIT Gandhinagar	2014

### Selected Projects

**Aeroacoustics of vortex shedding around a stalled airfoil**, UIUC Spring 2021

- Predicted noise due to vortex shedding around an airfoil by numerically solving the Ffowcs Williams-Hawkings equation using the Farassat Formulation 1A.

**Nonlinear modal decomposition of transient fluid flows**, UIUC Spring 2020

- Developed a nonlinear modal decomposition framework to identify meaningful flow structures in transient fluid flows using deep convolutional autoencoders.

#### Commercial software for computational fluid dynamics

- Performed CFD simulations on Ansys Fluent to study passive flow control using vortex generators on an Onera M6 wing at UIUC in Fall 2016.
- Simulated non-Newtonian blood flow in an artery using Star CCM+ to study the effect of blockages on blood pressure at IIT Gandhinagar in Spring 2016.

## **Skills**

Programming: Python, MATLAB, Fortran, C.  
Machine Learning: Pytorch, Tensorflow, Stable Baselines.  
High Performance Computing: PETSC, MPI, OpenMP.  
CFD and CAD: Ansys Fluent, Star CCM+, Autodesk Inventor.  
Miscellaneous: Git (Version Control), Simulink, Latex.

## **Leadership**

**Coordinator**, Upward Bound, UIUC June–July 2021

- Designed and co-organized a two-day glider building workshop for high school students from underrepresented and minority groups.
- Facilitated the procurement of supplies required for the activity and led one of the online Zoom sessions to guide the students through the workshop.

**Teaching Assistant**, UIUC Fall 2019, 2020

- Led regular office hours, exam revision sessions and created tutorial problems to aid the students in the AE433: Aerospace Propulsion course.
- Listed in the “List of Teachers Ranked as Excellent for Fall 2019” at UIUC.

**Mentorship**, UIUC

- As a senior graduate student, mentored newly admitted graduate students on the software architecture of our group.
- Mentored and supervised an undergraduate student on their research project on numerical modeling and CFD in summer 2017.

**Events Coordinator**, Amalthea’ 13, IIT Gandhinagar May–October 2013

- Led a team of 21 students to plan and organize various technical events at Amalthea’13, the annual technical summit of IIT Gandhinagar.

**College Soccer Player**, IIT Gandhinagar 2013–2015

- Member of the IIT Gandhinagar soccer team and participated at two annual Inter-IIT tournaments.
- Captain of one of the five teams in an intra-college soccer league.

**Undergraduate Lead Teaching Assistant**, IIT Gandhinagar Fall 2013

- Designed and led the lab sessions on using Autodesk Inventor in the Engineering Graphics course for freshman students.