Nirmal J. Nair

email: nirmaljp6@gmail.com | tel: 217-305-1356 | website: nirmaljp6.com

Education

University of Illinois at Urbana-Champaign, Urbana, Illinois — 2018 – present
Ph.D., Aerospace Engineering — GPA: 3.96/4.0
Concentration: Computational Science and Engineering

University of Illinois at Urbana-Champaign, Urbana, Illinois — 2016 – 2018
M.S., Aerospace Engineering — GPA: 4.0/4.0

Indian Institute of Technology Gandhinagar, Gujarat, India — 2012 – 2016
B.Tech. (*Honors*), Mechanical Engineering — GPA: 9.24/10.0

Research Interests

- Computational fluid dynamics
- Numerical modeling
- High performance computing
- Deep learning
- Reinforcement learning
- Reduced-order modeling

Research Experience

Graduate Research Assistant — September 2018–present
Ph.D. thesis adviser: Prof. Andres Goza, UIUC, Champaign, IL

- Developed a scalable and efficient numerical solver for simulating fluid-structure interaction problems using MPI and PETSC.
- Numerically studied the utility of covert-feather-inspired passive flow control technique for enhancing aerodynamic performance.
- Developed a state estimation approach where real-time sensor data was used to reconstruct the flow state using deep neural networks.
- Currently designing a closed-loop feedback controller for covert-feather-inspired active flow control using reinforcement learning.

CSRI Summer Intern — June 2019 – August 2019
Adviser: Dr. Kevin Carlberg, Sandia National Laboratories, Livermore, CA
Guaranteeing convergence of ROMs on nonlinear manifold using transfer learning.

- Developed an adaptive manifold refinement strategy to enable convergence of ROMs on manifolds built using deep convolutional autoencoders on Tensorflow.

Graduate Research Assistant — August 2016 – August 2018
M.S. thesis adviser: Prof. Maciej Balajewicz, UIUC, Champaign, IL
Data-driven reduced-order modeling of advection-dominated fluid flows.

- Developed a novel data-driven reduced order model for steady-state, advection-dominated fluid flows containing moving shocks.

Summer Undergraduate Research Fellow — May–July 2015
Adviser: Prof. Austin Minnich, California Institute of Technology, Pasadena, CA

- Designed and fabricated a prototype consisting of thermoelectric generators to power wireless temperature sensors in aircraft.

Summer Research Internship Program — May 2014–April 2015
Adviser: Prof. Vinod Narayanan, IIT Gandhinagar, India

- Performed local stability analysis of axisymmetric thermal boundary layer in response to heating and cooling.

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: Latex, Git (Version Control).

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
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 about a stalled airfoil, UIUC Spring 2021
- Predicted noise due to vortex shedding about 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.

Passive flow control using vortex generators, UIUC Fall 2016
- Performed CFD simulations on Ansys Fluent to study passive flow control using vortex generators to delay shock induced flow separation on an Onera M6 wing.

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.

Teaching Assistant, UIUC Fall 2019, 2020
- Led regular office hours and exam revision sessions to aid the students in the AE433: Aerospace Propulsion course.
- Listed in "List of Teachers Ranked as Excellent for Fall 2019" at UIUC.

Mentor, Summer Undergraduate Research, UIUC Summer 2017
- Mentored and supervised an undergraduate student on their research project on numerical modeling and CFD.

College Soccer Player, IIT Gandhinagar 2013–2015
- Member of the IIT Gandhinagar soccer team and participated at two annual Inter-IIT tournaments.

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.

Undergraduate Teaching Assistant, IIT Gandhinagar Fall 2013
- Designed and led the lab sessions on using Autodesk Inventor in the Engineering Graphics course for freshman students.