ADITYA RAJ – CV

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Research overview

My research focuses on developing a physical understanding of high-dimensional chaotic systems, for example, atmospheric and oceanic dynamics, through the lens of dynamical systems theory. I investigate spatiotemporal chaos using simplified models to uncover fundamental principles governing these complex behaviors. Key objectives include understanding the impact of short- and long-range couplings on chaotic dynamics and determining whether these dynamics can be effectively described using reduced-dimensional representations. Additionally, I'm studying nonequilibrium pattern formation, and currently exploring Rayleigh-Bénard convection, using simple model equations.

Education

1. PhD in mechanical engineering from Virginia Tech, Blacksburg, USA, *Aug 2021 - Exp Mar 2026*
2. Master's in mechanical engineering from IIT Dhanbad, India, *Aug 2017 - May 2019*
3. Bachelor's in mechanical engineering from MIT Muzaffarpur, India, *Aug 2011 - May 2015*

Work Experience

Graduate Teaching Assistant
Department of Mechanical Engineering, Virginia Tech, Blacksburg, USA – *(Jan 2025 - Present)*
GTA in Fluid Dynamics Lab.

- Conducting laboratory sessions
- Grading student reports
- Helping students in office hours

Graduate Research Assistant
Paul Research Group, Department of Mechanical Engineering, Virginia Tech, Blacksburg, USA – *(May 2022 - Dec 2024)*

- Studying spatiotemporal chaos in spatially extended systems influenced by short- and long-range couplings, as seen in fluid dynamics equations such as the Navier-Stokes equations.
- Investigating coupled map lattices (CMLs) and partial differential equations (PDEs), utilizing tools such as covariant Lyapunov vectors (CLVs) to analyze chaotic behavior in high-dimensional systems.
- Studying pattern formation in Rayleigh–Bénard convection using the Generalized Swift-Hohenberg equation and studying how mean flow strength can affect the tangent-space dynamics.

Graduate Research Assistant
CEHMS Group, Department of Mechanical Engineering, Virginia Tech, Blacksburg, USA – *(Jan 2022 - May 2022)*

- Studied bistable energy harvesting, especially using the phenomenon of stochastic resonance.
- Manufacturing bistable energy harvester capable of snap-through mechanism.
- Performing experiments to characterize the stiffness of bio-inspired bistable energy harvesting.

Graduate Teaching Assistant
Department of Mechanical Engineering, Virginia Tech, Blacksburg, USA – *(Aug 2021 - Dec 2021)*
GTA in ME 3624 Mechanical Design Lab.

- Conducting laboratory sessions
- Grading student reports
- Helping students in office hours

Project Assistant III
Aerosystems Laboratory, CSIR-CMERI, Durgapur, India – *(Aug 2019 - Mar 2020)*
Project: Design of Pressure Regulating and Shut-Off Valve (PRSOV) for the Environmental Control System (ECS) of aircraft.

- Drafting and Solid Modelling.
- Inspection of blueprints.
- Brainstorming for design improvements.
- Mathematical Modeling for flows through orifices.

Teaching Assistant
Department of Mechanical Engineering, IIT(ISM), Dhanbad, India – *(Aug 2018 - May 2019)*

- Teaching students to solve quiz problems.
- Proctoring.

Publications

1. **A. Raj** and M. R. Paul. Exploring the role of diffusive coupling in spatiotemporal chaos. *Chaos: An Interdisciplinary Journal of Nonlinear Science,* 34(10), 2024. https://doi.org/10.1063/5.0210661
2. **A. Raj**, J. P. Varun, and P. K. Mahato. Fabrication and vibration damping analysis of basalt fiber reinforced composite beam. In AIP Conference Proceedings, volume 2134. AIP Publishing, 2019.

Skills

- MATLAB: With 10+ years of experience I have developed code for numerical analyses of coupled map lattices, partial differential equations and small projects involving computational fluid dynamics such as lid-driven cavity. I've also used it for frequency domain analysis of vibrations of composite beams.
- Python: Intermediate level proficiency.
- Academic writing: Authored a journal paper and a conference paper.
- Autodesk Inventor: Used this 3D modeling tool proficiently at my stint at CSIR-CMERI Durgapur.
- ANSYS: Used it for a term project involving the calculations of a fluid flow in a lid-driven cavity.

Awards

- Graduate Aptitude Test in Engineering (GATE) Scholarship, Ministry of Human Resource Development, Government of India. *(July 2017 - May 2019)*

Presentations

1. **A. Raj** and M. R. Paul, Exploring the role of long-range coupling on chaotic fluid flows using Lyapunov vectors, Bulletin of the American Physical Society (2024). Presentation at APS DFD 2024.
2. **A. Raj** and M. R. Paul, Using Covariant Lyapunov Vectors to Investigate the Role of Spatial Interactions in Chaotic Fluid Systems, Bulletin of the American Physical Society (2023). Presentation at APS DFD 2023.
3. **A. Raj** and M. R. Paul, The Spatiotemporal Chaos of Coupled Maps: Insights from the Covariant Lyapunov Vectors. Presentation at SIAM DS 23 (2023).
4. **A. Raj** and M. R. Paul, Building a Physical Understanding of Spatiotemporal Chaos using Covariant Lyapunov Vectors. Presentation at SIAM SEAS (2023).
5. **A. Raj** and M. R. Paul, Exploring the Spatiotemporal Chaos of Lattices of Coupled Maps with Diffusive and Convective Spatial Interactions. Poster Presentation in Walter O'Brien Graduate Research Symposium at Virginia Tech (2023).
6. **A. Raj** and M. R. Paul, Exploring the Role of Spatial Coupling in Spatiotemporal Chaos Using Covariant Lyapunov Vectors, Bulletin of the American Physical Society (2023). Presentation at APS March Meeting 2023.
7. **A. Raj** and M. R. Paul, Using Covariant Lyapunov Vectors to Explore Chaotic Dynamics with Long-Range Spatial Coupling, Bulletin of the American Physical Society (2022). Poster Presentation at APS DFD 2022.

Extra-curricular

- System administrator for the Fall Fluid Mechanics Symposium 2024 at Virginia Tech.
  - Built the website for the symposium and sorted the sessions.
  - Chaired a session in the symposium.
- Webmaster for the grad student org MEGSC (Mechanical Engineering Graduate Student Council) at Virginia Tech. (March 2023 - Present)
  - Designed and managed the website and the SharePoint website for MEGSC.
- Peer mentoring
  - Peer mentor for ME department's Graduate Peer Mentor Program at Virginia Tech (Fall 2024 semester).
  - Peer mentor for MEGSC's peer mentoring program (Fall 2023 semester).
- Served as the president of the grad student org GEA (Graduate Engineering Alliance) at Virginia Tech (Jan 2023 - Dec 2023).
- Ranked 1st in a poster drawing competition in undergrad (BTech) at MIT Muzaffarpur.

Hobbies and interests

Chess, table-tennis, hiking, movies, art.