ADITYA RAJ – CV

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Research overview

My research explores complex, high-dimensional systems that exhibit collective dynamics and emergent behavior ubiquitous in nature. Using computational and theoretical approaches, I investigate how interactions, coupling structures, and network organization influence system behavior. By combining tools from dynamical systems theory, such as Lyapunov analysis and covariant Lyapunov vectors, with models of spatially extended and networked systems, I aim to uncover general principles governing the underlying topology, predictability, and pattern formation in complex systems.

Education

1. PhD, Department of Mechanical Engineering, Virginia Tech, Blacksburg, USA, *Aug 2021 - Exp May 2026*
2. M. Tech., Department of Mechanical Engineering, IIT Dhanbad, India, *Aug 2017 - May 2019*
3. B.Tech., Mechanical Engineering, MIT Muzaffarpur, India, *Aug 2011 - May 2015*

Summer program:

4. Complex Systems Summer School 2025, Santa Fe Institute, Santa Fe, New Mexico, USA. *June, 2025*

Work Experience

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

- Conducted laboratory sessions
- Graded student reports
- Advised students in office hours

Graduate Research Assistant
Paul Research Group, Department of Mechanical Engineering, Virginia Tech, Blacksburg, USA – *(May 2022 - Dec 2024, Summer 2025)*

- 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 (GSH) 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.
- Contributed in the construction of bistable energy harvester capable of snap-through mechanism.
- Assisted in performing the 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.

- Conducted laboratory sessions
- Graded student reports
- Advised 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 Modeling.

- Performed inspection of blueprints.
- Brainstormed for design improvements.
- Contributed in building mathematical models for flows through orifices.

Teaching Assistant
Department of Mechanical Engineering, IIT(ISM), Dhanbad, India – *(Aug 2018 - May 2019)*
- Taught students to solve quiz problems.
- Proctored quiz sessions.

Publications

1. **A. Raj** and M. R. Paul. Spatiotemporal chaos with long-range spatial coupling. (under review)
2. **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
3. **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.

Presentations

1. **A. Raj** and M. R. Paul, A dynamical systems perspective on spatial couplings in large chaotic systems. Presentation at Fall Fluid Mechanics Symposium 2025, Virginia Tech.
2. **A. Raj** and M. R. Paul, Building a physical understanding of the role of spatial couplings in high-dimensional chaotic systems. Poster presentation at Walter O'Brien Graduate Research Symposium 2025, Virginia Tech.
3. **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.
4. **A. Raj** and M. R. Paul, Exploring the role of long-range coupling on chaotic fluid flows using Lyapunov vectors). Presentation at Fall Fluid Mechanics Symposium 2024.
5. **A. Raj** and M. R. Paul, Using covariant Lyapunov vectors to explore spatiotemporal chaos: from coupled maps to PDEs. Poster presentation at Walter O'Brien Graduate Research Symposium at Virginia Tech (2024).
6. **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.
7. **A. Raj** and M. R. Paul, The Spatiotemporal Chaos of Coupled Maps: Insights from the Covariant Lyapunov Vectors. Presentation at SIAM DS 23 (2023).
8. **A. Raj** and M. R. Paul, Building a Physical Understanding of Spatiotemporal Chaos using Covariant Lyapunov Vectors. Presentation at SIAM SEAS (2023).
9. **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).
10. **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.
11. **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.

Awards

1. Complex Systems Summer School Scholarship, Santa Fe Institute, New Mexico, USA. *(June 2025)*
2. Graduate Aptitude Test in Engineering (GATE) Scholarship, Ministry of Human Resource Development, Government of India. *(July 2017 - May 2019)*

Skills

- MATLAB: With 10+ years of experience, I have developed code for the numerical computations of coupled map lattices, partial differential equations and small projects involving computational fluid dynamics such as lid-driven cavity. I have 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.

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.
- Outreach chairperson for the grad student org MEGSC (Mechanical Engineering Graduate Student Council) at Virginia Tech. *(March 2023 - July 2025)*
  - 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.