ME Seminar

Data-driven analysis and modeling of complex systems: fluid dynamics & turbulence

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ABSTRACT

Complex systems, ubiquitous in physics and engineering, are typically constituted by a large number of interacting components and nonlinear dependencies that favor the emergence of self-organized dynamics. This presentation focuses on the improved physical and mathematical understanding of such systems. First, we demonstrate a novel methodology of studying a complex chaotic system, by segregating its self-similarity from intermittency. Within this framework, we investigate the small-scale dynamics of turbulent flows through the analysis of high resolution direct numerical simulation data of incompressible isotropic turbulence and turbulent channel flow. Leveraging the same framework, we construct a physics-based data-driven model of the Lagrangian evolution of turbulence small-scale dynamics, offering significantly higher accuracy and generalizability across turbulent flows. The second part of this work focuses on data-driven methods for inferring causal interactions in complex systems, with a focus on fluid dynamics. We identify critical limitations of the existing machinery to discover causal interactions in heterogeneous dynamical systems and propose an alternative measure of information flow that is universally accurate. Integrating such methodologies with experimental and computational fluid dynamics opens new avenues of understanding complex flows.

ABOUT THE SPEAKER

Rishita Das is a postdoctoral researcher in the Mechanical and Aerospace Engineering department of New York University. She is working with Prof. Maurizio Porfiri in the areas of dynamical systems theory, information theory, and data science in complex systems. Rishita received her PhD in Aerospace Engineering from Texas AM University, where she worked with Prof. Sharath Girimaji in turbulence theory and modeling. She holds Bachelor and Master's degrees in Aerospace Engineering from Indian Institute of Technology Kharagpur, India, where she graduated with an Institute Silver Medal. She is also an Amelia Earhart Fellow and a DAAD-WISE scholar.

Rishita's doctoral dissertation research improves our understanding of small-scale processes in turbulence through novel theoretical approaches and analysis of direct numerical simulation data. Her developed data-driven model for velocity gradients accurately reproduces the small-scale dynamics of high Reynolds number turbulent flows. Her postdoctoral research focuses on data-driven methods and dynamical systems theory for improved quantification of nonlinear interactions in complex dynamical systems, with wide-ranging engineering applications. Her future interests are at the intersection of dynamical systems theory and data-driven methods, to study complex nonlinear systems, focused in the areas of fluid dynamics and turbulence.

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