Mathematics
Seminar

Vibrations, Structures, and Blood Flow: Unlocking the Power of Eigenvalues and Eigenvectors

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Abstract: Eigenvalues and eigenvectors are fundamental tools in understanding the behavior of complex systems, from structural vibrations to fluid flows. In this talk, we will examine their role in uncovering the intrinsic properties of matrices and how these insights extend to practical applications. Beginning with a mathematical foundation, we will explore how eigenvalues and eigenvectors emerge in modal analysis, a method used to analyze the vibrational behavior of physical structures, with examples ranging from the iconic Tacoma Narrows Bridge to finite element models of high-rise buildings.
We will then pivot to their use in hemodynamics, the study of blood flow, and how mathematics helps us understand it better. A powerful tool called Proper Orthogonal Decomposition (POD) uses eigenvalues and eigenvectors to break down complex blood flow data into its most important patterns, which makes it possible to analyze real-world data from ultrasound imaging, even when the data is noisy, in a relatively short time. By applying POD, we can better understand how blood moves through vessels and compute quantities like Wall Shear Stress (WSS), which is crucial for studying cardiovascular health.

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