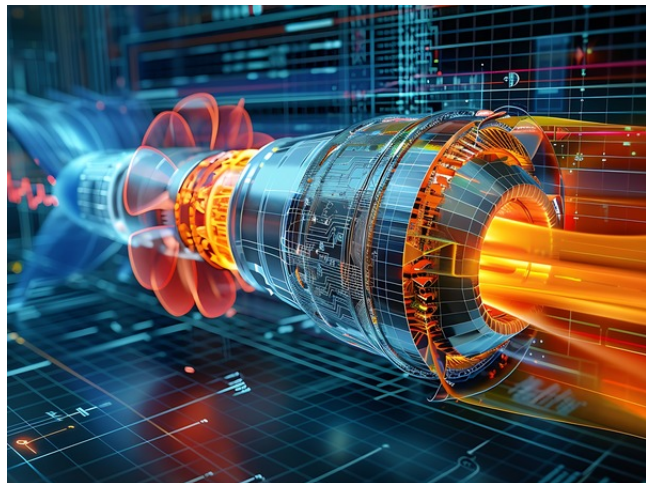


A Time-stepping Implementation of Randomized Resolvent Analysis

TECHNOLOGY NUMBER: 2024-420



OVERVIEW

Scalable computation of resolvent modes for large-scale fluid mechanics problems

- Efficient algorithm drastically reduces computational cost for large, complex simulations
- Aerodynamics design, climate modeling, energy systems, industrial fluid flows

BACKGROUND

Reduced-order modeling plays a crucial role in fluid mechanics by simplifying complex flow systems for analysis, control, and optimization. Resolvent modes, which characterize system responses to disturbances based on linear amplification mechanisms, have become powerful tools for studying turbulence and flow dynamics. Traditionally, calculating these modes has been computationally intensive, limiting their use to relatively small or simplified problems. Iterative and matrix-based approaches often suffer from scalability issues and excessive memory demands, making them impractical for high-resolution or real-world engineering applications. As modern engineering and scientific problems in aerodynamics, climate science, and energy production increasingly demand large-scale analyses, there is an urgent need for computational methods that can efficiently and accurately handle large datasets and complex geometries, making reduced-order models practical for solving modern, high-dimensional fluid mechanics challenges.

Technology ID

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Category

Software

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INNOVATION

This new method introduces a scalable, cost-effective approach for computing resolvent modes in fluid mechanics, enabling their application to much larger and more complex problems than before. Through efficient algorithm design, the approach drastically lowers both computational time and memory requirements while preserving accuracy. By overcoming prior limitations in scalability, this innovation opens the door for high-fidelity analysis and real-time control of complex flows in industrial, environmental, or biological systems. Real-world applications range from optimizing aerodynamic vehicle design and improving weather prediction models, to enhancing energy-efficient processes and understanding environmental water movements. The scalability and efficiency of the algorithm make it a valuable tool for engineers and scientists tackling large-scale fluid dynamic simulations in both research and industry.

ADDITIONAL INFORMATION

PROJECT LINKS:

DEPARTMENT/LAB:

- [Aaron Towne, Mechanical Engineering](#)

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