Center for Environmental & Applied Fluid Mechanics

"Understanding and Reducing the Impact of Ingested Particles on Gas Turbine Propulsion Engines"

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Abstract: An air vehicle trying to operate in adverse weather or wakes of urban canyons and mountainous terrains would be hit by strong large-scale atmospheric disturbances. In such extreme aerodynamic conditions, flight control becomes a great challenge, if not impossible, due to the enormous transient forces that the vehicle experiences. Currently, encounters with these extreme flow phenomena limit operations of fixed and rotating wing aircraft, especially those that are small to medium in size. The present study is focused on the analysis, modeling, and control of extreme aerodynamic flows, with unsteadiness far larger in amplitudes than those considered in traditional aerodynamics on a time scale comparable to those of the flow instabilities. The high dimensionality, strong nonlinearity, and multi-scale properties of these extreme flows make systematic analysis and control a tremendous challenge. Without the reduction of the state variable dimension and extraction of dominant dynamics, the application of dynamical systems and control theory for flight/flow control remains difficult. This talk will present our research group's recent efforts to model and control such complex fluid flows by leveraging data-driven techniques. We in particular will discuss the use of unsupervised and supervised machine learning techniques and how they can be embedded in existing flow analysis techniques. Equipped with these toolsets, we extract the essential inertial manifolds of extreme aerodynamics to facilitate the development of sparse and reduced-order models to design flow control techniques. Some of the successes in characterizing, modeling, and controlling extreme aerodynamic flows will be presented, followed by discussions on open problems and outlooks.

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