NASA SBIR/STTR Technologies

A2.04-9682 - Nonlinear AeroServoElastic Reduced Order Model for Active Structural Control

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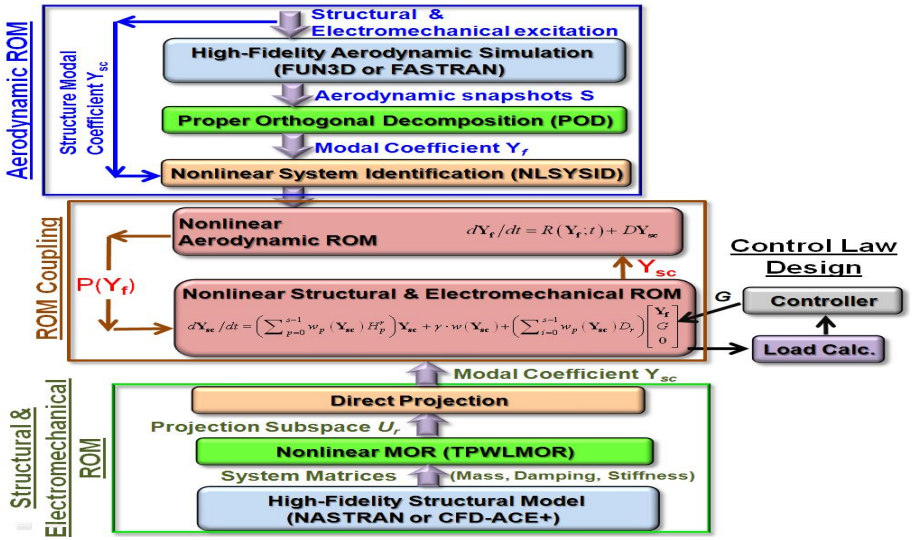
Identification and Significance of Innovation

Smart material-based structure control methodologies are broadly utilized to suppress the instabilities caused by LCO, buffet, and gust load. The capability to accurately analyze aeroelasticity in conjunction with control law design of the smart material actuators is essential for developing high-performance, safe, aerospace vehicles. The existing aeroelastic analysis techniques are ill-suited for aeroservoelasticity (ASE) due to several inherent limitations including prohibitive computational cost. We propose to develop rigorous reduced order model (ROM) algorithms and software to automatically generate nonlinear, parameterized ASE ROM. Key innovations include (1) incorporation of the smart material-based active structure control for integrated simulation; (2) hybrid methodologies to generate fast, high-resolution, nonlinear, parameterized ASE ROMs; and (2) a modular software framework to seamlessly integrate the entire process of ROM generation and computation, and verification.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

The overall project objective is to develop a software framework and rigorous ROM algorithms to automatically generate and compute the AeroServoElastic (ASE) ROMs for active control law design. The proposed effort will establish the proof-of-concept of applying nonlinear ROM techniques to analysis of the smart material-based active structural control. Specific Phase I objectives are: (1) developing a nonlinear aerodynamic ROM based on a hybrid Proper Orthogonal Decomposition-Nonlinear System Identification methodology; (2) developing a nonlinear structural & electromechanical ROM based on a Trajectory Piecewise Linear Model Order Reduction technique and Krylov subspace projection method; (3) establishing an integration scheme for coupled analysis of the aerodynamic, structural, and electromechanical ROM; (4) constructing a modular software framework enabling automated data exchange, ROM generation and computation, as well as verification; and (5) demonstrating the software by performing ASE case studies of NASA interest to establish the proof-of-principle of the technology. Phase II effort will focus on: (1) algorithm improvement in terms of execution efficiency, model parameterization, and automated parameter selection; (2) software environment enhancement (such as direct interface to NASA-relevant simulation tools and fully automated ROM process); and (3) extensive technology demonstration in complex scenarios.

NASA Applications

The proposed technology will provide a fast, accurate aeroservoelastic analysis tool with broad NASA applications, including: (1) performing computationally efficient analysis for optimal design of aerospace vehicles; (2) developing advanced, reliable aeroservoelastic control strategies (such as controlled maneuver and aeroelastic instability control, e.g., buffet, flutter, buzz, and control reversal); and (3) arranging test procedures for rational use of instruments and facilities.

Non-NASA Applications

The non-NASA applications focus on aerospace, aircraft, and watercraft engineering sectors involving fluid-structure-control interaction, including US Air Force, Missile Defense, Navy, business aircraft, automobile, and power industry etc. It can be used to (1) perform fault diagnostics and optimized design and (2) develop strategies for on-line process control.

Firm Contacts

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