NASA Glenn Faculty Fellowship Program

Glenn Research Center

Office/Division Name: LTV
Branch Name: Acoustics Branch
Research/Engineering Area / Topic: Implementation of Spectral Time-Resolved Proper Orthogonal Decomposition (SPOD) for comparison of experimental and numerical jet exhaust data

Description of Research/Engineering Work to Be Performed

Brief background and NASA mission/program support
NASA's Commercial Supersonic Transport (CST) Project studies aeroacoustics of supersonic vehicles specifically addressing the development of tools, technologies, and knowledge that will help eliminate technical barriers to practical commercial supersonic flight. In addition to sonic boom assessment and mitigation, CST's research includes maximizing cruise performance of propulsion systems and airframes for supersonic flights, minimizing airport noise and community annoyance, and reducing the impact of high-altitude emissions.

Objective(s) of project
Airport noise is one of the major technical challenges facing commercial supersonic flight. NASA's CST project uses experiments in conjunction with physics-based simulations, such as Large Eddy Simulation (LES), to explore aeroacoustic phenomenon in jet exhaust systems. Although advances in computational resources has made scale-resolving simulations more accessible in recent years, LES results have not been able to accurately replicate some important experimental observations for complex nozzle geometries. Dynamic data analysis techniques that are applicable to both experimental and numerical data can help identify and localize relevant flow structures responsible for the observed discrepancies. Spectral Proper Orthogonal Decomposition (SPOD) is one such technique used to identify coherent structures and relevant dynamic modes in the flow. Similar to the classical Proper Orthogonal Decomposition (POD) technique, SPOD finds orthogonal basis functions and decomposes the flow field into energy-ranked modes. However, unlike the POD, the resulting 'SPOD modes' vary in both space and time, thereby allowing extraction of spatio-temporal coherence in the data. A careful reconstruction of the SPOD basis functions can reveal relevant temporal and spatial scales, thereby allowing a more efficient comparison between LES and experimental data.

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Mission Performance/Requirements
The summer faculty will develop (in Matlab or Python) Spectral Proper Orthogonal Decomposition (SPOD) algorithm and implement it on existing time-resolved, high-speed schlieren, Particle Image Velocimetry, and/or LES data. The fellow will provide guidance regarding the physical interpretation of SPOD basis functions and perform reconstruction of flow field, thereby allowing comparison of experimental and LES data of jet exhaust systems.

Expected Outcome(s)
A well-documented Spectral Proper Orthogonal Decomposition algorithm amenable for use with both experimental and numerical data is expected from this project. A final report documenting the SPOD algorithm, workflow, and interpretation of results for an example case is also expected at the end of the fellowship.

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