A non-overlapping domain decomposition method for acoustic liner optimization

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ABSTRACT

The growth in commercial aviation results in significant efforts from aircraft engine manufacturers to minimize the environmental impacts of their products. In a typical conventional turbofan engine, fan noise accounts for a major portion of the overall noise emission. The most common technique to mitigate this noise source is the installation of acoustic liners. Existing numerical techniques dealing with the optimization of the liner parameters are computationally very intensive. The main objective of this work is to use non-overlapping domain decomposition method to reduce the computational cost in the liner optimization process.

The idea is to solve the global problem iteratively using a non-overlapping domain decomposition technique. The FETI-2LM method was first applied to Helmholtz problem by Bourdonnaye *et. al.* [1] which introduces 2 Lagrange multipliers or the dual variables on the inter- faces of the partitioned subdomains. The three main computationally intensive tasks in the method are the initial factorization of the local subdomain matrices, the successive forward-backward substitutions to solve the local problems and the modified Gram-Schmidt orthogonalization [2]. The first task requires a significant computational effort, although this cost is independent of the number of iterations to converge. However, the cost for the latter two tasks is highly dependent on the number of iterations required for the convergence of the interface problem. In the context of an optimization process, this global problem needs to be solved hundreds to thousands times for varying liner parameters.

One of the common ways to model bulk-reacting acoustic liners is to describe the liner as an equivalent fluid which is governed by the Helmholtz equation with equivalent, complex-valued density and equivalent bulk modulus. Each medium is subdivided into non-overlapping subdomains in such a way that each geometric partition has only one physical media. In this way, at a particular frequency, one can easily modify the liner properties without having to recompute and store the LU factors in the duct. The key results which will be presented in this work include the verification of the FETI-2LM applied to heterogeneous Helmholtz equation. The optimization workflow will be presented in 2D for the test case of a lined duct. The relevant cost and memory savings compared to a conventional optimization workflow will be highlighted. This improved optimization method will help tackle realistic 3D nacelle geometries to identify optimal liner parameters for a desired range of frequency.

REFERENCES

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