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LEVEL SET TOPOLOGY OPTIMIZATION OF COUPLED MECHANICAL-ACOUSTIC PROBLEMS

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Abstract: Many acoustic devices such as hearing aids and loudspeakers exhibit strong interaction between mechanical vibrations and acoustic pressure due to high internal pressure levels coupled with lightweight flexible materials. Density-based topology optimization using the mixed formulation has been proposed to design such coupled systems and has been successfully applied to 2D systems [1]. However, high computational costs make an extension of the approach to realistic complex 3D geometries challenging. The level-set approach with body-fitted meshes and design updates based on the Hamilton-Jacobi equation has also been employed to the coupled mechanical-acoustic optimization problem [2], but suffers also from high computational costs due to re-meshing in each design iteration. Recently, a BESO approach combined with heuristic sensitivity analysis has appeared also [3] but the heuristics make the approach unsuitable for system exhibiting strong coupling. The present work employs the level set design parametrization with the geometry of the interface between the vibrating solid and the acoustic region described via the zero contour of an explicit level set function. The immersed boundary method is used to capture the geometry on a fixed and un-fitted mesh using the cutFEM method [4]. The level-set values are explicitly used as design variables allowing the use of efficient math programming tools facilitating the development of a computationally efficient framework for optimizing strongly-coupled mechanical acoustic interaction problems. The developed framework is demonstrated with optimization examples where the minimization of acoustic pressure in certain objective domain is considered.

References

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