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TOPOLOGY OPTIMIZATION METHODS FOR ACOUSTIC-MECHANICAL COUPLING PROBLEMS

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Abstract. A comparative overview of methods for topology optimization of acoustic-mechanical coupling problems is provided. The goal is to pave the road for developing efficient optimization schemes for the design of complex acoustic devices such as hearing aids.

Topology optimization methods have gained tremendous popularity in the last decades and are now used routinely e.g. in aviation and automotive industries. Applications have spread from pure mechanics to various physics such as heat transfer, fluid mechanics, optics and acoustics. However, a major challenge exists when considering problems that involve coupling of physics through boundaries including acoustic-mechanical coupling where structural vibrations and acoustic pressure interact at the boundary. Analysis methods that require boundary tracking is difficult to combine with a traditional density-based parametrization (pixel- or voxel-based design description) and a varying topology. This calls for alternative analysis and/or design parametrization schemes to be developed.

A mixed finite element approach was proposed earlier[1], in which the pressure was introduced as an auxiliary variable. This allowed the element physics to be interpolated between acoustics and structural vibrations with use of standard design parametrization. Another approach was proposed using a level-set design parametrization[2]. Here, a level-set function explicitly separates the physical domains and facilitates the boundary coupling formulation.

In this work we compare variants of two mentioned formulations as well as a newly proposed scheme[3] based on acoustic and mechanical computations on fictitious domains and globally assembled coupling without explicit boundary tracking.

Keywords: Topology Optimization, Acoustic-Structure Interaction.

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