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TRANSIENT TOPOLOGY OPTIMIZATION OF VIBRO-ACOUSTIC PROBLEMS

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Abstract: The need for improved performance of small acoustic devices such as hearing aids and smartphones is ever increasing. As the devices become smaller they are becoming subject to more complex signals while experiencing strong transient coupling between acoustic pressure and structural vibrations. Transient finite element simulations and topology optimization are the essential elements to improve and meet future demands of coupled acoustic-mechanical systems. The aim of this work is to demonstrate the possibilities of applying transient topology optimization to acoustic-mechanical interaction problems. Topology optimization is an iterative procedure which optimizes material distribution in a design domain while minimizing an objective function. Usually, frequency domain analysis is considered the current state-of-the-art for the optimization of vibro-acoustic problems. However, this approach causes issues especially when large-scale models are considered, due to the indefiniteness of the resulting linear systems. Employing transient analysis for the modeling and optimization is a promising alternative to overcome these issues. In this work, mixed Finite Element Method is utilized for the modeling of the coupled acoustic-structural system which is particularly suited for topology optimization since standard design parametrization can be utilized to interpolate between acoustics and structural mediums. Transient optimization of acoustic-mechanical interaction problems allows us the design efficient structures where acoustic pressure signals are tailored as a result of the optimization. Several optimization cases are presented which demonstrates the advantages of transient optimization including acoustic pulse envelope shaping using the Hilbert transform.