Boundary Element Methods in Acoustics

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In the last years, the increased awareness of modern societies towards noise pollution has led to tighter regulations regarding the noise levels emitted by vehicles, machinery etc. The newly established thresholds elevate the importance of controlling sound and thus the NVH behavior has become a crucial factor in the design phase of each new machine or vehicle. However, as deploying physical prototypes for the different iterations of a particular design could inflict a tremendous increase of cost and time, numerical simulations are used to extract some of the basic NVH characteristics of each iterated design. Specifically, numerical models can predict the dominant composition of the emitted noise and the effect of potentially adding damping material.

As replacing physical prototypes by verified models is common practice in physics and engineering, it is essential to select the proper numerical method for each different simulated event. Regarding acoustic simulations in the low frequency regime, element based methods constitute the most established tools to produce a numerical prediction. A big part of element based methods, termed as the boundary element methods (BEM), are solely based on surface elements to yield information for the response of the whole 3D domain. Apart from the use of a mere surface mesh, inherently fulfilling the radiation to infinity boundary condition renders them the most appropriate for infinite space problems such as the ones encountered commonly in acoustics, soil dynamics etc.

The focus of this seminar is the implementation of the BEM in acoustic simulations. First, the two basic formulations of BEM in acoustics are derived, i.e. the direct and indirect approach. Then, after comparing the two approaches, respective remedies are introduced that attempt to mitigate the most prominent side effect of using the BEM, i.e. irregular frequencies. Finally, a brief comparison between BEM with FEM in terms of their accompanying computational cost is performed and the relatively recent speed-up advancement of combining the Fast Multiple Method in BEM is presented. The seminar is concluded by demonstrating the setup and analysis of a test case.

Recommended reading

[1] Brebbia, C. A. (1980). The boundary element method for engineers (No. BOOK). Pentech press.

[2] Marburg, S., & Nolte, B. (2008). Computational acoustics of noise propagation in fluids: finite and boundary element methods (Vol. 578). Berlin: Springer.

[3] Kirkup, S. (2019). The boundary element method in acoustics: A survey. Applied Sciences, 9(8), 1642.