Downloaded from orbit.dtu.dk on: Sep 17, 2019

DTU Library

Benefits and Challenges when Performing Robust Topology Optimization for Interior Acoustic Problems

Christiansen, Rasmus Ellebæk; Jensen, Jakob Søndergaard; Lazarov, Boyan Stefanov; Sigmund, Ole

Publication date:
2014

Document Version
Peer reviewed version

Link back to DTU Orbit

Citation (APA):
Christiansen, R. E., Jensen, J. S., Lazarov, B. S., & Sigmund, O. (2014). *Benefits and Challenges when Performing Robust Topology Optimization for Interior Acoustic Problems*. Abstract from 4th International Conference on Engineering Optimization, Lisbon, Portugal.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Benefits and Challenges when Performing Robust Topology Optimization for Interior Acoustic Problems

Authors:
Rasmus Ellebæk Christiansen[1], Jakob Søndergaard Jensen, Boyan Stefanov Lazarov, Ole Sigmund.
Department of Mechanical Engineering, Technical University of Denmark.

Abstract

The objective of this work is to present benefits and challenges of using robust topology optimization techniques for minimizing the sound pressure in interior acoustic problems. The focus is on creating designs which maintain high performance under uniform spatial variations. This work takes offset in previous work considering topology optimization for interior acoustic problems, [1]. However in the previous work the robustness of the designs was not considered.

We consider a 2D acoustic problem with hard wall boundaries in the frequency domain. The pressure field is introduced by a source vibrating at a single frequency in the low to medium frequency regime. The Helmholtz equation is discretized using quadrilateral first order finite elements. A design sub-domain is defined where material may be placed to alter the reflections in the room. A continuous design field is introduced and The Method of Moving Asymptotes (MMA) [2], is used to perform the optimization. A smoothing filter is used for regularization and a projection step to obtain clean designs combined with a continuation scheme to avoid stagnation during the optimization iterations, [3]. A min/max formulation is used for robust optimization where each realization of the design field is obtained by varying the projection level corresponding to an erosion/dilation of the design.

It is found that the designs quickly increase in complexity when increasing the source frequency. Even for moderate frequencies the underlying design field varies rapidly without any apparent regularity. This means that no predictable correlation between a variation of the projection level and a spatial variation of the design exists. Consequently robust optimization using the min/max approach with projection is not suitable unless a high number of realizations is used. A novel double filter approach is suggested and we show that the problem of the rapidly varying design field can be eliminated by applying this filter. Additionally we show that the problem to some extend can be removed by applying the well known penalization approach on the intermediate filtered design variables.

A comparison of the approaches is performed where designs which provide significant sound pressure reduction are presented and their performance under spatial variation analyzed. Using both the double filter and the penalization approach it is shown that designs obtained using standard topology optimization are highly sensitive towards near uniform erosion and dilation. It is then shown that designs optimized using the double filter and the robust approach maintain a significantly better performance under spatial variations of identical magnitude. Finally the sensitivity of both sets of designs towards perturbations in the source frequency is investigated.

[1]E-mail: raelch@mek.dtu.dk
Address: Nils Koppels Allé 404, DK-2800 Kgs. Lyngby, Denmark

References

[1] Dühring, M. B.; Jensen, J. S. & Sigmund, O. *Acoustic design by topology optimization.* Journal of Sound and Vibration 317, Pages 557-575, 2008.

[2] Svanberg Krister, *The Method of Moving Asymptotes - A New Method for Structural Optimization.* International Journal for Numerical Methods in Engineering 24, Pages 359-373, 1987.

[3] Wang, F.; Lazarov, B. S. & Sigmund, O. *On Projection Methods, Convergence and Robust Formulations in Topology Optimization.* Structural Multidiciplinary Optimization 43, Pages 767-784, 2011.