Controlling geometry in topology optimization: grey scale, filtering, robustness and uncertainties

By Ole Sigmund, Villum Investigator, Dept. of Mechanical Engineering, Technical University of Denmark

Means for geometry control in topology optimization are needed to prevent: numerical artefacts like checkerboarding and mesh-dependence; ensure minimum length-scale and thus manufacturability; ensure robustness to manufacturing errors; and to incorporate specific features or deficiencies of manufacturing processes like overhang constraints, enclosed voids and maximum feature sizes.

This Master Class takes outset in the simple element density parameterization (SIMP) for topology optimization and discusses issues like grey scales, realizability, length scales, benchmarking and gives and overview of recent developments in robust design formulations and inclusion of random effects.

To get the full benefit of the class, the attendees are recommended to have downloaded and worked with one or more of the Matlab codes published in refs. [1,2,3] and publicly available at www.topopt.dtu.dk. An overview of educational codes also covering other branches of topology optimization is found in [4]. It is also recommended to read ref. [5] for an overview of filtering methods and [6] for background and good scientific practice in the field.

Reading material

[1] Sigmund, O., A 99 line topology optimization code written in MATLAB, *Structural and Multidisciplinary Optimization,* **2001***, 21*, 120-127

[2] Andreassen, E.; Clausen, A.; Schevenels, M.; Lazarov, B. & Sigmund, O., Efficient topology optimization in MATLAB using 88 lines of code, *Structural and Multidisciplinary Optimization,* **2011***, 43*, 1-16

[3] Ferrari, F. & Sigmund, O., A new generation 99 line Matlab code for compliance Topology Optimization and its extension to 3D, *Structural and Multidisciplinary Optimization,* **2020***, 62*, 2211–2228

[4] Wang, C.; Zhao, Z.; Zhou, M.; Sigmund, O. & Zhang, X., A comprehensive review of educational articles on structural and multidisciplinary optimization, *Structural and Multidisciplinary Optimization,* **2021***, 64*, 2827–2880

[5] Wang, F.; Lazarov, B. & Sigmund, O., On projection methods, convergence and robust formulations in topology optimization, *Structural and Multidisciplinary Optimization,* **2011***, 43*, 767-784

[6] Sigmund, O., On benchmarking and good scientific practise in topology optimization, *Structural and Multidisciplinary Optimization,* **2022***, 65*, 315