A REVIEW OF TOPOLOGY OPTIMIZATION APPROACHES

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Summary The topology optimization method has undergone a tremendous development since its introduction in the seminal paper by Bendsøe and Kikuchi in 1988. By now, the concept is developing in many different directions including “density”, “level-set”, “topological derivative”, “evolutionary” and several others. The paper gives and overview, comparison and critical review of the different approaches, their strengths, weaknesses, similarities and dissimilarities and suggests guidelines for future research.

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A number of prior developments within homogenization theory and numerical optimization methods provided the foundation for the seminal paper on numerical topology optimization by Bendsøe and Kikuchi in 1998 [1]. Since the original “homogenization approach to topology optimization” the concept has developed in a number of different directions including: a) the density approach [2, 3, 4]; b) the level-set approach [5, 6]; c) topological derivatives [7] and d) evolutionary approaches [8]. The density and evolutionary approaches use simple element or nodal-based design variables whereas the level-set approach, which in 2D must be combined with topological derivatives, uses shape derivatives for the development of the optimal topology. Lately, hybrid approaches have appeared, such as level-set approaches that use shape derivatives for design updates but, somewhat against the original definition of the level-set concept, do allow for introduction of holes without the use of topological derivatives [9]. Also, it seems that the filtered density fields used in recent projection techniques [10, 11, 12, 13] are becoming more and more similar to the level-set function used in the level-set approaches.

Based on above observations, it seems timely to perform a comparative and critical review of topology optimization approaches. How should different approaches by categorized? What are the strengths and weaknesses of various approaches? What is the efficiency of various approaches? Which approaches show the biggest potential and widest applicability? May there be possibilities for further merging of methods for the benefit of speed of convergence? Are there directions of developments which are missing?

The paper will try to give answers to above questions and hopefully form a basis for future nomenclature, discussions and developments in the exciting and rewarding area of topology optimization.

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