EngOpt2018 - 6th International Conference on Engineering Optimization
Instituto Superior Técnico, Lisbon Portugal • 17-19 September, 2018
Editors: H.C. Rodrigues, J. Herskovits, C.M. Mota Soares, et al.

Abstract ID 1170

CONSTRAINT AGGREGATION IN TOPOLOGY OPTIMIZATION

Eduardo Fernández Sánchez[1], Maxime Collet[2], Simon Bauduin[1], Pablo Alarcón Soto[1], Pierre Duysinx[3]

[1]University of Liège, Belgium
efsanchez@uliege.be, s.bauduin@uliege.be, palarcon@uliege.be

[2]Univeristy of Liège, Belgium
maxime.collet@uliege.be

[3]University of Liege, Belgium
p.duysinx@uliege.be

Keywords: Local Constraints,Aggregation,p-mean,p-norm,Manufacturing Constraints

Abstract: A vast amount of the methods that address local design requirements introduce a wide set of constraints within the optimization problem. This local formulation calls for the use of aggregation functions in order to avoid the computational burden on the optimizer. This step of collecting the constraints within a few representative ones seems as a simple implementation detail coming at the final stage of the formulation. Therefore it is often neglected in the discussion. However if this aggregation step is not well treated the success of the whole method may be compromised, and in many cases the simplest part of the constraint becomes time-consuming or even, the hardest point of the formulation. Aggregation functions are built to be smooth and differentiable approximations of the max function. In addition their sensitivity information should be smooth in order to be used in efficient continuous optimization algorithms. They have also to catch accurately the most critical constraints to mimic the locally constrained problem. The classical application is in the field of stress constraints, where a large amount of contributions have been made on the subject. Most of the research contributes with new aggregation techniques, which are adapted to the context of topology optimization with stress constraints. However, to tailor high quality global manufacturing constraints, we need to make further progress in the understanding of the aggregation functions when used in the topology optimization. To this end, we perform a deep theoretical investigation and a quantitative numerical assessment of the behavior of these functions when being used in different formulations of manufacturing and mechanical constraints. Specifically, we focus the study on p-mean and p–norm functions within the framework of density methods. We include in the analysis methods to introduce: i) maximum size control, ii) minimum gap between solid members, iii) minimum size, iii) overhang control for additive manufacturing and iv) stress constraints. Some important observations obtained from this study are: p-norm depends on the amount of data that is being aggregated, making it more unstable under mesh refinement. On the other hand, p-mean is less dependent on mesh modifications but it is likely to produce results that do not satisfy every local constraint. In addition, by looking at the sensitivities it is possible to have an insight of the nonlinearity of a method, which could be used as a criterion to know whether it is necessary or not to alter the aggregation function.