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Data-fitted constraint aggregation schemes

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Constraint aggregation is a way to reduce the size of the dual problem of a constrained optimization problem by replacing n_c similar constraints with a single, aggregated constraint. In this contribution, especially the local volume constraints by Wu et al. [1] are studied, since employing them in a topology optimization (TO) problem usually leads to one constraint per finite element of the model.

Commonly used constraint aggregation functions, like e.g. the p-norm, p-mean, or Kreisselmeier-Steinhauser (KS) [2] function, include a tunable aggregation parameter "p". Increasing p also increases the accuracy of the approximation of the maximum (worst) value of all n_c original constraints by the aggregated constraint. On the downside, an increase of p also increases the nonlinearity of the aggregated constraint, possibly leading to convergence issues. Therefore, it is desirable to keep p as low as possible without compromising the quality of the approximation by the aggregated constraint.

However, the choice of a specific aggregation parameter p is often not justified in the literature. Local volume constraints are used in the context of TO e.g. to enforce redundant designs [1], for which the robustness to partial failure is implicitly increased, or to enforce a maximum feature size [3]. Although the same constraint equations can be used for both cases, a value of $p = 16$ is sufficient in [1], and, depending on the studied geometry, values up to $p = 300$ are used in [3]. In this contribution, very high values of p are seen as an indication, that the chosen aggregation function is not well suited for the studied problem. Therefore, alternative aggregation functions based on the p-norm are introduced, that offer an additional parameter to adapt the aggregation characteristics to the expected distribution of the data being aggregated. This results in higher accuracy also for very low p values when compared to known aggregation functions.

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