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ADAPTIVE STRATEGIES FOR FAIL-SAFE TOPOLOGY OPTIMIZATION

Olaf Ambrozkiewicz, Benedikt Kriegesmann

Hamburg University of Technology, Germany
olaf.ambrozkiewicz@tuhh.de, benedikt.kriegesmann@tuhh.de

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Abstract: For components which are critical for safety, it is desirable that the structure is tolerant to partial damage, i.e. that multiple, redundant load paths exist and the structure is fail-safe. A method to embed a fail-safe requirement in topology optimization using the SIMP approach has first been proposed by Jansen et al. [Struct Multidisc Optim, 2013]. Their approach consists of removing single isolated patches from the design domain. However, the number of patches to consider is very high in order to make sure that all possible damage scenarios are covered. Since for each patch the equilibrium system is solved, the number of patches drives the computational cost and makes the approach unfeasible for practical applications. Zhou and Fleury [Struct Multidisc Optim, 2016] suggested to only consider a subset of all possible damage patches arranged such, that a minimal hideout volume for the possible damage is achieved. Still, a regular grid of the damage patches is used and only the denseness of the spatial distribution of the patches is reduced. In order to achieve a further reduction of damage cases, two strategies can be pursued: Either an Active-Set strategy which only considers the most critical patches out of the full set of patches according to a certain criterion, or an adaptive placement of damage patches. In the current contribution, two approaches that follow these strategies are implemented and compared to existing approaches. The first approach is referred to as threshold method. It consists of reducing the number of patches simply by considering only patches with densities above a certain threshold. The computational effort especially at the beginning of the simulation can be significantly reduced. For the overall simulation the effort could be reduced by about 50%, without sacrificing performance of the final design. The second approach makes use of the fact, that following the approach of Jansen et al. the maximum compliance of all damage scenarios is minimized. Therefore the optimization is driven by the worst-case scenarios and the influence of the non-critical patches is close to zero, and hence, they need not to be considered. This motivates the method of an adaptive placement of worst-case patches. The optimization task is modified to a nested optimization, where the location and shape of the most critical patches is determined and the compliance is only determined for these worst-case patches.