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# EFFICIENT TRANSIENT TOPOLOGY OPTIMIZATION THROUGH DYNAMIC SUBSTRUCTURING

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**Abstract:** Transient topology optimization is known to be computationally expensive and thus less attractive than its steady state counterparts. A large portion of the execution time is spent on the transient analysis, including both the time integration of the governing finite element equations and the additional terminal value problem, which is required by the sensitivity analysis using the adjoint method. This work develops a methodology for reducing the computational effort through the usage of dynamic substructuring methods. For achieving this, a component mode synthesis, namely the Craig-Bampton method, is applied to reduce the degrees of freedom of the system. The reduced system gained by the substructuring is utilized both for the computation of the state vectors and the sensitivities. The main idea of the substructuring method is to decompose the design domain into a number of substructures, or components, and hence avoiding a global assembly. The system matrices of these substructures are reduced in size, by describing the dynamic behaviour of the internal degrees of freedoms both by their static response subject to a unit displacement of each degree of freedom on the boundary to the other substructures, and a number of vibrational modes with fixed boundary. Then, the reduced system matrices are assembled from the reduced substructure matrices, whereby the system can be reduced by orders of magnitude compared to the original and global system, and the same is true for the computational expense of the transient analysis. But this comes with the cost of computing a set of reduction bases in every iteration of the optimization. Furthermore, the reduced system only represents an approximation of the full system, and hence there will be an error, when the substructuring is applied. This deviation from the full system is well understood when it comes to the state vectors. But this work will also perform a study on the consistency of the sensitivities by taking the dependency of the reduction bases on the design variable into account when formulating the expression for the sensitivities. This topic has not gotten any attention in the literature so far. Results show that using dynamic substructuring methods, the computational effort can be reduced significantly, while at the same time achieving similar results in terms of the optimized density distribution to the ones from the optimization bases on the full system.