Robust shape optimization with small uncertainties

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In this talk we propose two approaches for dealing with small uncertainties in geometry and topology optimization of structures. Uncertainties occur in the loadings, the material properties, the geometry or the imposed vibration frequency. A first approach, in a worst-case scenario, amounts to linearize the considered cost function with respect to the uncertain parameters, then to consider the supremum function of the obtained linear approximation, which can be rewritten as a more 'classical' function of the design, owing to standard adjoint techniques from optimal control theory. The resulting 'linearized worst-case' objective function turns out to be the sum of the initial cost function and of a norm of an adjoint state function, which is dual with respect to the considered norm over perturbations.

A second approach considers objective functions which are mean values, variances or failure probabilities of standard cost functions under random uncertainties. By assuming that the uncertainties are small and generated by a finite number N of random variables, and using first- or second-order Taylor expansions, we propose a deterministic approach to optimize approximate objective functions. The computational cost is similar to that of a multiple load problems where the number of loads is N.

We demonstrate the effectiveness of both approaches on various parametric and geometric optimization problems for elastic structures in two space dimensions.

The talk is based on joint work with Charles Dapogny (LJK, Grenoble).

References:

[1] G. Allaire, Ch. Dapogny: A linearized approach to worst-case design in parametric and geometric shape optimization, *M3AS* Vol. 24, No. 11 (2014) 2199-2257. HAL preprint: hal-00918896, version 1 (December 2013).

[2] G. Allaire, Ch. Dapogny, A deterministic approximation method in shape optimization under random uncertainties, *submitted to SMAI J. Comp. Math.* HAL preprint: hal-01160256v1 (June 2015).