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Isogeometric shape optimization of 3D shell structures

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Shape optimization aims at finding the optimal shape of a structure with respect to a specific objective. Typical objectives are maximum stiffness, minimum weight, etc. For shells, and in particular for thin shells, the overall structural behaviour is crucially determined by their shape. An optimal shape for minimizing the weight, for example, carries all loads preferably by membrane forces without any bending moments which guarantees an efficient use of the material. Shape optimization of shells is impossible without contributing to their very special mechanical behavior.

Applying the isogeometric concept to shape optimization, the distinction between CAD-based and node-based optimization is redundant since both models rely on the same geometric basis. Therefore, the advantages of both approaches can be combined, and furthermore, the whole process of design, analysis and shape optimization can be integrated into one geometric model.

Nevertheless, together with the new paradigm of IGA there appear new technical challenges for the shape optimization with IGA. We discuss three of them. First, it is important to carefully distinguish between analysis and optimization model and the various levels of intermediate refinements of the latter. This approach is presented for shape optimization of thin shells, based on isogeometric shell analysis as presented in [1-5]. Second, it appears that as consequence of the large and varying supports of open NURBS basis functions the shape sensitivities need additional treatment. That is a new observation. The presented solution is crucial for non-convex problems which are the standard case of shape optimization of shells. Third, dealing with multi patches is a demanding aspect as well.

Besides the promising methodological aspects of IGA based shape optimization the paper will discuss several principal aspects of shape optimal design of shell structures, as there are: The properties of large, non-convex design spaces, the non-uniqueness of shape parameterization, and how to treat them, as well as the utility and futility of optimal solutions which IGA based optimization shares with other techniques.

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