Isogeometric Shape Optimization in the context of Solid-shell Models

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ABSTRACT

Shape optimization appears naturally as a promising application of Isogeometric Analysis (IGA). By using spline functions as finite element bases, IGA reconciles computer-aided design (CAD) with structural analysis. Therefore, the entire design lifecycle of a structure can be contained within a single platform [1] making structural design much easier and faster. The efficiency of IGA-based shape optimization has been observed [1-3] and capable algorithms have been proposed. A major benefit is the possibility of choosing the design space independently from the analysis space. Both spaces describe the exact same geometry and are initially obtained through different refinement levels of the CAD model [2]. This multilevel design approach allows to properly define the design parameters and it also enables to perform computations on a rich and suitable analysis model. In sum, IGA-based shape optimization quickly leads to simple and good quality optimal design. Hence, we explore with interest in this work the possibilities of using isogeometric solid-shell models [4] to optimize the design of thin structures. Advantages of solid-shell elements against classical shells are multiple and one of interest is the simplicity of coupling different patches and element types. Complex structures as skin stiffened aerostructures present many parts which interact. Using isogeometric solid-shell simplifies modelling and analysing these structures. First, we compare the use of solid-shell elements with the use of Kirchhoff-Love elements on simple shape optimization examples. This highlights the contributions and the difficulties encountered with isogeometric solid-shell based shape optimization. Then, we present the problem of optimal design of a stiffened panel. Non-conforming interface between the stiffeners and the skin is needed in order to get an attractive design space. Thank to the use of solid-shell models, the compatibility of the displacements is easily enforced by resorting to mortar methods [5].

REFERENCES

[1] A. J. Herrema, N. M. Wiese, C. N. Darling, B. Ganapathysubramanian, A. Krishnamurthy, M.-C. Hsu, “A framework for parametric design optimization using isogeometric analysis”, *Computer Methods in Applied Mechanics and Engineering*, pp. 944-965, (2017).

[2] J. Kiendl, R. Schmidt, R. Wüchner, K.-U. Bletzinger. “Isogeometric shape optimization of shells using semi-analytical sensitivity analysis and sensitivity weighting”, *Computer Methods in Applied Mechanics and Engineeing*, pp. 148-167, (2014).

[3] Z.-P. Wang, M. Abdalla, S. Turteltaub. “Normalization approaches for the descent search direction in isogeometric shape optimization”, *Computer-Aided Design*, pp. 68–78, (2017).

[4] R. Bouclier, T. Elguedj, A. Combescure. “An isogeometric locking-free NURBS-based solid-shell element for geometrically nonlinear analysis”, *International Journal for Numerical Methods in Engineering*, pp. 774-808, (2015).

[5] R. Bouclier, J.-C. Passieur, M. Salaün. “Local enrichment of NURBS patches using a non-intrusive coupling strategy: Geometric details, local refinement, inclusion, fracture”, *Computer Methods in Applied Mechanics and Engineering*, pp. 1-26, (2016).