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CAD-integrated Parametric Design Cycle for Structural Membranes

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Abstract
The design cycle of membrane structures consists of three interactive and highly nonlinear disciplines. Formfinding is performed in order to find a geometry that allows the prestressed structure to carry loads through tension only. Once a formfound geometry is set, structural analysis needs to assess the structure's safety and usability. The most challenging step is the cutting pattern generation, which aims at finding the planar pieces which can be elevated to build spatial membrane structures with a minimum deviation from the desired shape and prestress state. Since membrane surfaces are typically double-curved, they cannot be developed into planar geometries. An optimization approach is necessary to solve this problem. The Variation of Reference Strategy (VaReS) [2] is an innovative optimization approach, which simulates the actual mounting process in a mechanically accurate way.

Isogeometric B-Rep Analysis (IBRA) [1] allows the designer to perform analyses on the original CAD model without leaving the CAD environment. High quality is ensured for the geometry and the mechanical approximation by using NURBS for both the geometry representation and the shape functions. Additionally, the topology information of multipatches can be transferred to the analysis in order to enrich the design space. Since the entire CAD model can be accessed, trimmed surfaces can thus be included in the analysis. Parametric models allow the designer to examine a large variety of geometrical and mechanical entities with one model.

CAD-integrated parametric analysis with IBRA elements has a large potential as the design cycle of a membrane structure - form finding, structural analysis and cutting pattern generation - can seamlessly be integrated into CAD systems. This contribution gives a brief overview of IBRA and its inherited advantages for the whole design cycle. A special focus is put on the advanced method of cutting pattern generation with the Variation of Reference Strategy and IBRA elements.

References

[1] M. Breitenberger et al.Analysis in computer aided design: Nonlinear isogeometric B-Rep analysis of shell structures, in *Computer Methods in Applied Mechanics and Engineering* vol. 284, pp. 401-457. doi 10.1016/j.cma.2014.09.033 (2015).

[2] A. Widhammer, Variation of Reference Strategy. Generation of Optimized Cutting Patterns for Textile Fabrics, *Dissertation at Technische Universität München*, Munich (2015).