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Isogeometric analysis and form finding for thin elastic shells

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Abstract
Recent developments within the design of shells have seen an increased interest in utilizing active bending in form giving [1]. This enables complex structures to be built from basic or off the shelf materials. However, the form of these types of structures is highly entwined with the material properties, which makes the design of bending active systems reliant on physical simulations to understand their behaviour. An associated problem with this process is the integration between modeling and analysis, as the final design is an equilibrium shape. Today, different geometric descriptions are mainly used for modeling and analysis, with Non-Uniform Rational B-Splines (NURBS) being most common for design, whereas classical Finite Element Analysis (FEA) operates on meshes with polynomial description.
This paper proposes the formulation of geometrically nonlinear IsoGeometric Analysis (IGA) as a way of enabling elastic deformation within a design process. IGA is a rather new development within the field of computational mechanics that uses the definition of NURBS as the underlying geometric description [2]. The paper applies Kirchhoff-Love shell theory [3] for the simulation of thin sheets undergoing large deformations, and goes on to describe an approach to approximate target geometries through deformations by adapting a specific material distribution. Thus, a curved geometry can be found as the result of deforming a flat piece, analogous with a construction process, incorporating the material behaviour and associated stress into the final form. By adapting a common geometry base, the proposed method embeds controlled deformations natively in a design process.

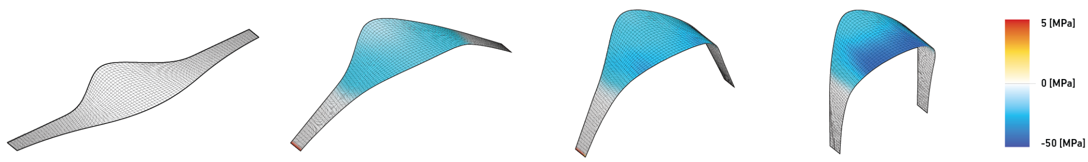

Figure 1: Process of forming a flat sheet (left) into a predefined form (right) showing stress in the bottom fibre

References

[1] R. La Magna, *Bending Active Plates*, Ph.D Dissertation, University of Stuttgart (2017)

[2] J.Cottrell, T.Hughes, Y.Bazilevs *Isogeometric Analysis*, Wiley (2009)

[3] J.Kiendl *Isogeometric Analysis and shape optimal design of shell structures*, Ph.D Dissertation, TU Munich (2010)