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A One-Dimensional Model for Developable Elastic Strips with Isogeometric Discretisation

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Numerous engineering applications consider thin-walled structural parts, one example being flexible flat cables in the development of computer hardware. Classical shell models control such slender objects via their base surface in order to decrease the involved number of degrees of freedom and thereby the numerical costs. This contribution reduces a strip-shaped Kirchhoff-Love shell with developable base surface to its base curve by both analytic and numerical techniques.

Several research contributions [1] specialised the shell model to the case of isometric deformations of developable base surfaces. Recently, this lead to shell descriptions depending only on independent variables along a curve on the surface [2].

The framework of rectifying developable surfaces suffers from problems that arise with vanishing curvature of the directrix. We circumvent these issues by utilising a relatively parallel frame [3], which generalises the concept to curves with points or segments of vanishing curvature. An optimisation problem with non-linear geometric constraints and boundary conditions yields the equilibrium state of the shell as its local minimum.

An isogeometric discretisation of the optimisation parameters provides the smoothness necessary for this framework and yields considerable results even for a small amount of control points, i.e. coarse discretisations. We illustrate the applicability of our approach at hand of some examples and study the numerical behaviour.

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