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ANISOTROPIC GROWTH OF THIN SHELLS WITH SUBDIVISION ELEMENTS

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Numerical simulations of thin shells and membranes undergoing large deformations are computationally challenging. Depending on the scenario, they may spontaneously buckle, wrinkle, fold, or crumple. Nature's thin tissues often experience significant anisotropic growth, which can act as the driving force for such instabilities. We employ a recently developed finite shell element [1] to simulate the rich variety of nonlinear responses of anisotropically growing Kirchhoff-Love shells. The element is based on Loop subdivision surface shape functions [2] in order to guarantee convergence of the method, and to allow a finite element description of thin shells in the classical Rayleigh–Ritz formalism. Requiring no rotational variables or auxiliary degrees of freedom, a thin shell representation of this kind is remarkably simple to implement and superior to traditional approaches in terms of computational costs. We illustrate the great potential in this approach by simulating various geometrically nonlinear scenarios like the inflation of airbags, cylinder buckling, wrinkling at the free boundaries of leaves and torn plastic sheets (Fig. 1), as well as the folding of spatially confined growing sheets. Our model offers great flexibility for studying complex nonlinear interactions between stretching, bending, and growth of thin tissues.

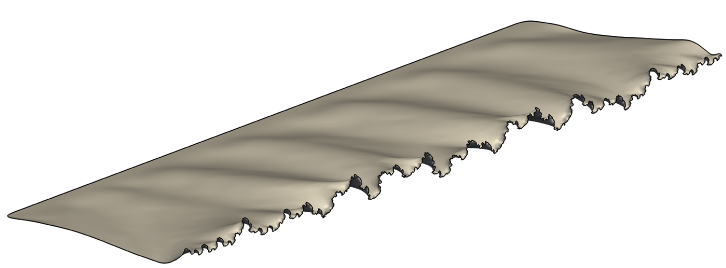

Figure 1: Self-similar wrinkles along the edge of a torn plastic sheet.

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