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Finite Element Methods for the Stretching and Bending of Thin Structures with Folding

We study the elastic behavior of prestrained thin plates which can undergo large deformations and achieve non-trivial equilibrium shapes even without external forces. The mathematical problem consists in minimizing an energy of the form $E(\mathbf{y}) = E_S(\mathbf{y}) + \theta^2 E_B(\mathbf{y})$, where $\mathbf{y}$ is the deformation of the midplane, θ is the thickness of the plate, E_S is the (nonconvex) stretching energy, and E_B is the bending energy.

We introduce a discrete energy based on a continuous finite element space and a discrete Hessian operator involving the jump of the gradient of the deformation across the interelement sides. We establish the Γ-convergence of the discrete energy and also present an energy-decreasing gradient flow for finding critical points of the discrete energy. We provide numerical simulations illustrating the capabilities of the model.

This is joint work with A. Bonito and A. Morvant (Texas A&M).