
A model for curvature-induced morphing of hyper-elastic shells

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Abstract

The deformation of slender structures is largely described by the most famous theorem in differential geometry, the Gauss’ theorem egregium, which states that infinitesimally thin objects deform into shapes that preserve lengths. Therefore, as a consequence of their slenderness, thin structures largely deform by bending with small amounts of stretching, often via elastic instabilities. Active and biological membranes exploit this type of mechanism in their morphing strategies, usually undergoing large strains and large rotations. To investigate the effect of material non-linearities in the morphing of thin, and naturally curved, slender objects, in this work we derive an effective two dimensional energy functional via a formal dimensional reduction of a three dimensional Neo-Hookean morphoelastic material. We include the role of a non-mechanical stimulus via the multiplicative decomposition of the deformation gradient tensor which considers the presence of an incompatible configuration that, in our case, is associated to a prescribed incompatible curvature stimulus (1). We also include the role of a through-the-thickness adaptation during the morphing, following the work of (2).

The energy functional that we derive is suitable to be implemented in finite element codes. We thus use our model to investigate how non-linearities affect the curvature-induced snapping of spherical caps.

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