Discrete differential geometry-based model for the snapping analysis of axisymmetric shells

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Abstract

Axisymmetric shells can be found in numerous scenarios in both the natural environments and engineering applications, thus an efficient model would be crucial for the comprehensive understanding on their mechanical behaviors. In this work, we propose a novel discrete model for the nonlinear buckling and snapping analysis of axisymmetric shells based on differential geometry theory. Based on discrete differential geometry, the axisymmetric shell is discretized into interconnected one-dimensional elements along the longitudinal direction, and the in-plane stretching and out-of-bending potentials of shell mid-surface are formulated based on the geometric principles, and, therefore, the model can naturally incorporate geometric nonlinearities associated with large deflections and rotations. We first verify the developed discrete model through the quantitative comparison with the theoretical models and finite element simulations reported in literature. Next, with the developed model, we systematically investigate the bistability and the snap-through inversion of a spherical shell under indentation, in which the nonlinear boundary contact is involved. A simple geometric model is later built to reveal the contact mechanism between the flexible shell and the rigid indenter. In addition, the magnetic-induced snapping of axisymmetric shell is also systematically investigated by incorporating our discrete numerical model with magneto-elastic constitutive relation.

M.L. acknowledges the financial support provided by the University of Birmingham through a Start-up grant.