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Computational synthesis and analysis of internal resonances in transverse vibrations of hyperelastic plates

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ABSTRACT

There has been renewed interest in the research community on the use of materials other than silicon to construct micro-electro mechanical systems that can provide several desired properties such as low cost, weight, and bio-compatibility. One of the major classes of these materials being used extensively is hyperelastic polymers, some of whom may have electrostrictive properties. In parallel, there has also been renewed interest in the use of non-linear dynamics principles to enhance device functionalities. In this study, the authors propose to merge these two streams of thought and develop a framework for synthesizing structural configurations representing hyperelastic plate resonators that can undergo nonlinear 1:2 internal resonances. These various configurations can be used in a variety of sensing or other applications. For structural synthesis, a heuristic computational method based on the finite element method is employed to iteratively design candidate plates for 1:2 internal resonances. The method is designed so as to yield topologies which are easy to fabricate. Assuming a two-parameter Mooney–Rivlin Model for the material behavior, a reduced-order model that can be used to obtain the nonlinear equations of motion for the structure is derived by following a Lagrangian approach. These equations retain dependence on the constitutive material parameters and are analyzed to understand the nonlinear dynamics of various plate structures, all exhibiting the 1:2 internal resonance response behavior.