Dynamics and Elasticity of Origami-based Beams

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Abstract

We consider origami-inspired deployable beams consisting of rigid and extensible links connected by torsional springs. First, we study a discrete model and develop the system of ordinary differential equations of motion for multiple degrees of freedom, describing the complete dynamics of the system. Then, we create a homogenized model that allows us to substitute an extensive system of discrete equations with several coupled partial differential equations for continuum functions. The equations of generalized elasticity, such as micropolar and microstretch continua, are expected to represent the continuum media. For both models, dispersion relations are derived and compared. It is shown that the discrete linear model for the rigid links beam introduces severe constraints and limits the possible wave propagation. At the same time, continuum linear models for both extensible and rigid link beams lose the lowest (acoustic) mode compared to their discrete counterparts. Possible solutions for these paradoxes are discussed.
The dynamics of the origami-based beam are simulated using the particle-based method to solve constrained equations of motion explicitly. The resulting continuum model is assumed to be easier to deal with and more suitable for large-scale simulations. Possible applications include the use of shape-morphing materials as advanced sensors and actuators for soft robotics, space solar batteries and antenna deployment, medical stents, and other applications.

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