

Coupled Origami Tubes for Stiff Deployable Structures

G.H. Paulino, E. T. Filipov, T. Tachi

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Abstract

Thin origami sheets can be assembled into three dimensional structures that can be used for practical engineering applications. This work explores the stiffness of deployable origami tubes that can be used as cantilever structures with a high orthogonal stiffness. A unique “zipper” configuration is used to couple the tubes, which makes the systems easy to deploy, yet stiff for other deformation modes [1]. The glide reflection of zipper tubes provides coupling in a way that activates both clockwise and counter-clockwise rotation of individual tubes leading to a net result in which those rotations balance each other (in contrast, with aligned tubes, those rotations are of the same sign and thus comping each other). The self-restricting geometry of the coupled tubes limits local deformations and makes the systems stiff for out-of plane loading. This research provides a study on how geometric variations of the origami tubes affect stiffness and deployment characteristics. In particular, the sector angle of each individual tube is varied to identify how this parameter influences the structural properties. The global deployment characteristics are explored using eigenvalue band-gaps, and indicate that tubes with lower sector angles are easy to deploy yet also stiffer for unintended motions. Cantilever analyses show that the geometry of the coupled tubes can significantly affect the stiffness: some tube combinations have a high stiffness throughout deployment, while others only have a high stiffness when fully deployed. Parametric studies are used to show optimal geometries for the coupled tubes that maximize the eigenvalue bandgaps and the stiffness throughout the deployment. The coupled tubes could serve applications in medical devices, adjustable robotic arms, and deployable space booms with a reliable extension sequence.



Figure 1: Paper model of the original “zipper” coupled origami tubes. Photo courtesy of Rob Felt.

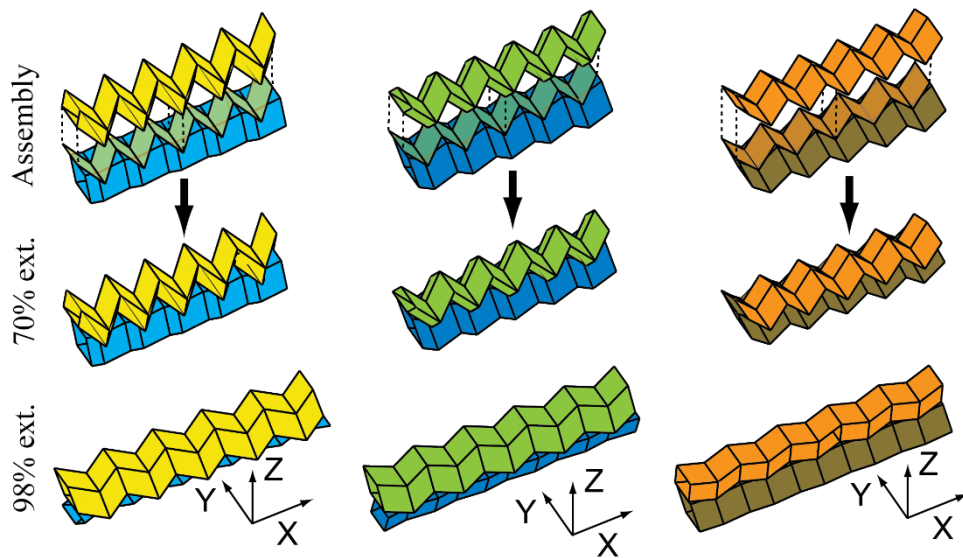


Figure 2: Three sample cases of zipper coupled origami tubes

[1] Filipov ET, Tachi T, Paulino GH. (2015) “Origami tubes assembled into stiff, yet reconfigurable structures and metamaterials.” *Proceedings of the National Academy of Sciences USA*, Vol. 112, pp.12321-12326.