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Mechanical Engineering Seminar Series

Programming and Predicting the Effective Shapes of Origami and Kirigami Surfaces

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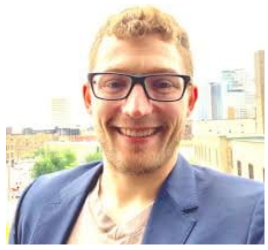

Room 1010 DOW

Tuesday, November 15, 2022

4:00 p.m.

ME Seminar Zoom link

Passcode 309714

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Abstract
Shape-morphing finds widespread utility, from the deployment of small stents and large solar sails to actuation and propulsion in soft robotics. Origami and kirigami – patterns of cuts and folds in a sheet – are versatile platforms for shape-morphing, inspiring the design of many such structures and devices. However, it remains a challenge to design patterns that morph into a specified surface on demand and to predict their response to a broad range of loads and stimuli. This talk explores the general design and modeling principles for origami and kirigami structures.

In the first part of the talk, we develop an efficient algorithm that explicitly characterizes the designs and deformations of a large class of easily deployable origami. We then employ this algorithm in an inverse design framework to approximate a general surface by this family of origami. The origami structures produced by our framework can be manufactured on a flat reference sheet, deployed to their target state by a controlled folding motion, then to a compact folded state in applications involving storage and portability. In the second part of the talk, we describe a coarse-graining procedure to determine all the slightly stressed modes of deformation of a large class of periodic and planar kirigami. The procedure gives a system of nonlinear partial differential equations (PDE) expressing geometric compatibility of angle functions related to the motion of individual slits. Leveraging known solutions of the PDE, we present excellent agreement between simulations and experiments across kirigami designs. Together, these results both expand the engineering design space of origami and kirigami structures and provide a new frontier on which to model their mechanics under a broad range of stimuli.

Bio
Paul Plucinsky joined the faculty in the USC Department of Aerospace and Mechanical Engineering as an Assistant Professor in January 2020. Prior to USC, Paul was a Postdoctoral Scholar in Aerospace Engineering and Mechanics at the University of Minnesota. He received his Ph.D. in Mechanical Engineering at Caltech in 2017 and a B.S. in Civil Engineering, and an M.S. in Structural Engineering at the University of Michigan in 2011. His research interests lie at the interface of solid mechanics, materials science, and mathematics. He has applied this theory-guided approach to a range of topics, including nematic elastomer sheets, origami, and kirigami design, shape-memory alloys, and phase transitions in nano-structures.

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