Origami Inspired Design of Nonlinear Springs with Tunable Characteristics

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Abstract:
Origami-inspired design has recently emerged as a major thrust area of research in the fields of science and engineering. One such design utilizes Kresling pattern origami to construct nonlinear springs that can act as mechanical bit memory switches, wave guides, fluidic muscles, and vibration isolators. In this presentation, we report on the design of such springs and the characterization of their static equilibria and bifurcations as the geometric parameters of the Kresling pattern are varied. To this end, we develop a nonlinear model of the spring which assumes that the different panels can be represented by truss elements which undergo axial deformation and buckling. The model accounts for the rotary stiffness of the creases, and self-avoidance of the panels due to panel contact at small angles. Results of the modeling effort are validated against experimental data obtained using paper-based springs demonstrating the ability of the model to predict the qualitative and quantitative trends of the experiments. Based on these findings, a rubber-based springs is designed and, for the first time, successfully 3-D printed. This new concept can open new avenues for the design of nonlinear tunable springs.

Biography:
Mohammed F. Daqaq is a Global Network Professor of Mechanical Engineering at New York University, NY and New York University, Abu Dhabi. He received his B.Sc. degree in Mechanical Engineering from Jordan University of Science and Technology in 2001, and his M.Sc. and Ph.D. in Engineering Mechanics from Virginia Tech in 2003, and 2006, respectively. In 2006, he joined the Department of Mechanical Engineering at Clemson University as an Assistant Professor and went through the ranks to become a tenured Associate Professor in 2012. In 2016, Mohammed became the D. W. Reynolds endowed scholar of Mechanical Engineering at Clemson University. In 2017, Mohammed joined the ranks of New York University, Abu Dhabi. Mohammed’s research focuses on the application of various nonlinear phenomena to improve the performance of micro-power generation systems, micro-electromechanical systems, and vibration assisted manufacturing processes. Mohammed’s research is funded through several grants from the National Science Foundation including the 2010 CAREER award. His research has also been recognized at the national level through several awards including the 2016 C. D. Mote Jr. Early Career Award from the ASME Design Division, the 2014 Gary Anderson Early Achievement Award from the ASME Aerospace Division, the 2014 Eastman Chemical Award for research excellence, and the 2012 Clemson University Board of Trustees Award for Faculty Excellence. He is currently the Editor-in-Chief of the Elsevier Journal MethodsX Energy, and a Subject Editor for the Journal Nonlinear Dynamics.