MECHANICAL ENGINEERING SEMINAR

From Muscles to Plants – Nature-Inspired Multifunctional Adaptive Metastructures

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Abstract

In recent years, the concept of mechanical metastructures developed based on synergistic modular architectures has been explored. Such architectures are often observed in nature, such as in biological or atomistic systems. For example, the versatility of skeletal muscle is an inspiration towards the development of engineered adaptive structures and material systems. Mechanical modeling of muscle suggests that some of muscle's intriguing macroscale adaptivity results from the assembly of nanoscale, cross-bridge constituents that maintain multiple metastable configurations. Inspired by these observations, recent research explored a concept of creating modular structures from the assembly of mechanical, metastable modules, defined as modules that exhibit coexistent metastable states. Analytical and experimental results demonstrate that such modular metastructures may yield significant and valuable adaptivity including variation in reaction force magnitude and direction, numerous globally stable topologies, orders of magnitude change in stiffness, and tunable vibration and wave propagation characteristics. In another example, inspired by the physics behind the rapid plant movements and the rich topologies in origami folding, a unique class of multifunctional adaptive structure is created through exploring the innovation of fluidic origami. The idea is to connect multiple Miura folded sheets along their crease lines into a space-filling cell module, and fill the tubular cells in-between with working fluids. The pressure and fluid flow in these cells can be strategically controlled much like in plants for nastic movements. The relationship between the internal fluid volume and the overall structure deformation is primarily determined by the kinematics of folding. This relationship can be exploited so that fluidic origami can achieve actuation & morphing, programmable & recoverable energy absorption and tunable multistability by changing the internal fluid pressure, and stiffness tuning by constraining the fluid volume. This presentation will highlight some of these interdisciplinary research advances in nature-inspired multifunctional adaptive metastructures.

Biography

Kon-Well Wang is the Stephen P. Timoshenko Professor of Mechanical Engineering at the University of Michigan. He received his Ph.D. degree from the University of California at Berkeley in 1985, worked at the General Motors Research Labs as a Senior Research Engineer, and started his academic career at the Pennsylvania State University in 1988. During his Penn State years, Professor Wang has served as the William E. Diefenderfer Chaired Professor in Mechanical Engineering, Director of the Structural Dynamics and Controls Lab, Associate Director of the Vertical Lift Research Center of Excellence, and Group Leader for the Center for Acoustics and Vibration. Dr. Wang joined the University of Michigan in 2008, and has been the Department Chair of Mechanical Engineering from 2008 to 2018. Professor Wang's main technical interests are in adaptive structural systems and structural dynamics. He has received numerous recognitions for his accomplishments; such as the Pi Tau Sigma-ASME Charles Russ Richards Memorial Award, the ASME J. P. Den Hartog Award, the SPIE Smart Structures and Materials Lifetime Achievement Award, the ASME Adaptive Structures and Materials Systems Award, the ASME N. O. Myklestad Award, the ASME Rudolf Kalman Award, the ASME Adaptive Structures and Material Systems Best Paper Awards, the NASA Tech Brief Award, and the SAE Ralph Teetor Award. He is a Fellow of the ASME, AAAS, and IOP. Professor Wang has been the Chief Editor for the ASME *Journal of Vibration and Acoustics*. He is currently an Associate Editor for the *Journal of Intelligent Material Systems and Structures* and an Editorial Advisory Board Member for the *Journal of Sound and Vibration*.