Learning from Nature – Adaptive Metastructures for NVH

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Abstract

In recent years, the concept of mechanical metastructures developed based on nature-inspired synergistic modular architectures has been explored. For example, some of skeletal muscle's intriguing macroscale functionalities result from the assembly of nanoscale, cross-bridge constituents that maintain multiple metastable configurations. Inspired by this observation, recent studies investigated an idea of creating modular structures from the assembly of metastable mechanical or electrical modules, and demonstrated that such metastructures would yield valuable adaptivity, including reconfiguration of global topology, orders of magnitude change in stiffness, and tunable damping and non-traditional wave propagation characteristics. In another example, inspired by the physics behind the plant nastic movements and the rich designs of origami folding, a class of metastructures is created through exploring the innovation of fluidic origami cellular systems. The fluid pressure in these origami cells can be strategically controlled to achieve actuation & morphing, programmable energy absorption, and tunable mechanical properties and multi-stability. In addition, we introduce a framework of utilizing origami folding to redistribute the inclusions of a phononic structure to achieve significant bandgap adaptation. Cylindrical inclusions are attached to the vertices of a Miura-Ori sheet, whose simple rigid folding can enable fundamental reconfigurations in the underlying periodic architecture via switching between different Bravais lattice types. Such a reconfiguration can drastically change the wave propagation behavior in terms of bandgap and provide a scalable and practical means for broadband acoustic wave tailoring. This presentation will highlight some of these interdisciplinary research advances in nature-inspired adaptive metastructures for NVH controls.