Beneficial Nonlinear Design in Engineering:The X-Structure/Mechanism Approach

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Abstract

Nonlinearity can take an important and critical role in engineering systems and thus cannot be simply ignored in structural design, dynamic response analysis, and parameter selection. A key issue is how to analyze and design potential nonlinearities introduced to or inherent in a system of under study, which is greatly demanded in many practical applications involving vibration control, energy harvesting, sensor systems and robots etc. This talk will present an up-to-date review on a cutting-edge method for manipulation and employment of nonlinearity in engineering systems developed in recent years, named as the X-structure or mechanism approach. The method is inspired from animal leg/limb skeletons and can provide passive low-cost high-efficiency adjustable and beneficial nonlinear stiffness (high static & ultra-low dynamic), nonlinear damping (dependent on resonant frequency and vibration excitation amplitude) and nonlinear inertia (low static & high dynamic) individually or simultaneously. The X-shaped structure or mechanism is a generic and considerably simple structure or mechanism representing a class of beneficial geometric nonlinearity with realizable and flexible linkage mechanism or structural design of different variants or forms (quadrilateral, diamond, polygon, K/Z/S/V-shape, or others) which all share similar geometric nonlinearity and thus similar nonlinear stiffness/damping properties, flexible in design and easy to implement. This talk systematically reviews the research background & motivation, essential bio-inspired ideas, advantages of this novel method, beneficial nonlinear properties in stiffness, damping and inertia, and potential applications, and ends with some remarks and conclusions.