Graduate Student Research Seminar

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Design of meta-materials under finite, general deformation

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3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Meta-materials are artificial materials with periodic microstructures that are designed to target a specific effective material property. Typically, these materials are deigned such that the effective properties are different from naturally occurring homogenous materials. Previous research has been reported for designing linear (infinitesimal displacements and strains) meta-materials to achieve specific mechanical properties such as elastic moduli and Poisson's ratio. Different from these studies, another class of metamaterial design problems stem from the need of mimicking the deformation behavior of nonlinear materials such as elastomers or creating artificial materials to achieve a nonlinear deformation behavior that does not exist in nature. However, meta-material design for nonlinear large deformation behavior has not been well investigated due to two major challenges: (1) the classical unit cell topology optimization approach using the infinitesimal displacement asymptotic expansion method becomes invalid for nonlinear large deformation, and (2) representative volume element (RVE) based computational homogenization is computationally expensive for the nonlinear problems. In this research, by employing a generalized finite deformation asymptotic homogenization theory, a topology optimization problem is formulated and solved to design periodic meta-material microstructures for target non-linear responses. Furthermore, heterogeneous metamaterial structures subjected to general deformation modes can be designed by solving a coupled two-scaled problem derived from the finite deformation asymptotic homogenization theory.

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