ME PhD Thesis Colloquium

Topological derivative-based optimization of Fiber-reinforced Structures, Coupled Thermoelastic Structures and Compliant Mechanisms

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ABSTRACT

Topological derivative (TD) of a functional quantifies the sensitivity with respect to an infinitesimal domain perturbations such as a hole, an inclusion, a source term, a crack, etc. In this thesis, topological derivatives are used in conjunction with level-set method to optimize stiff structures and compliant mechanisms. In the first part of this thesis, we use topological derivatives in polar form to obtain fiber-reinforced structural designs with non-periodic continuous fibers that are optimally arranged in specific patterns. The distribution of anisotropic fiber material within isotropic matrix material is determined for given volume fractions of void and material as well as fiber and matrix simultaneously, for maximum stiffness. In this three-phase material distribution approach, we generate a Pareto surface of stiffness and two volume fractions by adjusting the level-set plane in the topological sensitivity field. The next part of this thesis deals with topology optimization of thermally coupled elastic structures. In this, we present two design examples: (i) battery pack for optimal heat dissipation; and (ii) thermomechanical actuators. In addition to the design of stiff structures, we perform topology optimization of compliant mechanisms using topological derivatives. In such elastically deformable structures, we adopt multicriteria formulation that aims to simultaneously attain desired displacement with adequate overall stiffness. The resulting compliant topologies reduce the occurrence of undesirable discrete compliance, particularly at low volume fraction of material. Finally, we derive topological derivative for homogeneous Dirichlet condition prescribed on the boundary of a hole. Here, we address the rationale behind the proposed ansätz in the asymptotic analysis of the solution using the second-order Green's tensor. In summary, the analytically derived topological derivative-based optimization approach makes it unique in terms of its computational efficiency and wide applicability for a variety of problems.

ABOUT THE SPEAKER

I am a PhD scholar in the Department of Mechanical Engineering at Indian Institute of Science, Bengaluru, working with Prof. G.K. Ananthasuresh in the field of design and optimization. I graduated in Mechanical Engineering from Institute of Technology and Management, Gwalior, in 2013. I did my M.E. in Mechanical Engineering Department from Indian Institute of Science, Bengaluru, in 2015. My research focuses on topological derivatives and its applications in topology optimization.

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