11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Design optimization for multifunctional 3D printed structures with embedded functional systems

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Abstract

This paper presents an optimization based approach for the design of additively manufactured (AM), or 3D printed, multi-material parts with embedded functional systems (for example, a structural part with electronic/electrical components and associated conductive paths). The main contribution of this paper is the coupling strategy that enables the structural topology optimization (TO) of a part to be carried out in conjunction with the internal system design. This is achieved by accommodating the effects of system integration on the structural response of the part within TO. This work aims to demonstrate that the presented coupled optimization approach provides improved designs for 3D printed circuit volumes (PCVs) which provide benefits including: optimal system design, miniaturization, circuit encapsulation (protection) and tailored structure-system performance.

The coupled optimization strategy outlined in this work consists of: 1) a placement method used to determine suitable component locations (influenced by information extracted from the skeleton i.e. medial axis of the structure), 2) a routing method for optimal shortest distance connections between points (here, Dijkstra's algorithm is used to route between two fixed points by tracing skeletal members), and 3) integration into a TO routine taking account of the effect of routing on structure and vice-versa. This paper will report the developments made on the proposed coupled optimization strategy by detailing how the results from automatic placement and routing techniques are considered for the TO.