GENERATIVE DESIGN AND TOPOLOGY OPTIMIZATION FOR MULTI-SCALE AND MULTI-MATERIAL ADDITIVE MANUFACTURING SOLUTIONS

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ABSTRACT

Generative design and topology optimization (TO) techniques have been gaining traction in the pursuit of optimal structural design, especially when targeting macro- and micro-scale levels concurrently. The ability to integrate different material properties, ranging from composites and functionally graded materials to multi-material systems, has opened new avenues for designing high-performance structures. These innovations are especially relevant in industries using Additive Manufacturing (AM), where precise control over both mechanical properties (macroscopic and microscopic) and manufacturability is crucial.

Numerical approaches, such as standard density-based, level-set, and homogenization techniques, are being used to account for complex behaviors occurring across different length scales, ensuring compatibility between different phases in multi-scale and/or multi-material structures. On the numerical front, traditional discretization-based strategies like the finite element method and isogeometric analysis are being augmented by AI-driven techniques, which can efficiently explore large design spaces and handle uncertainties in material behavior and external conditions. Moreover, new scalable algorithms are emerging to address complex multi-physics, multi-objective, and multi-constrained problems, ensuring that optimized designs are robust, manufacturable, and perform as designed.

For this session, we invite contributions that showcase recent advances in generative design and topology optimization, including (but not limited to) emerging mathematical models and numerical methods that improve structural performance, incorporate concurrent material optimization, or offer innovative solutions for managing uncertainties. We also welcome submissions that demonstrate real-world applications in the field of AM, aiming to foster fruitful discussions on how to best leverage TO for next-generation, manufacturable designs.