

A DENSITY-BASED FRAMEWORK FOR SIMULTANEOUS TOPOLOGY AND JOINT LOCATION OPTIMIZATION OF ASSEMBLIES

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Abstract

This paper presents a density-based approach for the simultaneous optimization of component topologies and joint locations in assemblies. As an extension of classical topology optimization, the proposed formulation treats the assembly as a coupled system consisting of multiple components. All components are embedded in a unified optimization and analysis model that shares a common mesh while assigning each component an individual design space. In addition to the material distribution within each component, the joint layout is a critical design aspect, as it can influence the resulting optimal topology of the components. Accordingly, the joints are modeled as volumetric cylindrical non-design bodies, while their center positions are introduced as additional design variables and optimized simultaneously with the component topologies. Unlike purely grid based descriptions, the joint positions are treated as continuous design variables, enabling flexible repositioning within the design domain. To ensure geometrically consistent designs and prescribed minimum clearances, distance constraints are imposed between components within the assembly. Furthermore, minimum distances between joint locations, as well as between joints and the design space boundary, are enforced. These constraints are formulated efficiently using differentiable morphological filtering operators, so that minimum clearances are reliably maintained. Several three-dimensional examples demonstrate the capability of the proposed approach. The results show that the joint positions are optimally aligned and that compliance is reduced compared to the case with the fixed positions.