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MODULAR-TOPOLOGY OPTIMIZATION OF STRUCTURES AND MECHANISMS: A FREE-MATERIAL OPTIMIZATION-BASED HEURISTICS

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Two contemporary research challenges are relevant to structural design: automation and sustainability. In this contribution, we address both of them within the *modular-topology* optimization framework, investigating (i) the design of module topologies, (ii) encoding admissible module connections, and (iii) placement of modules in multiple structures.

In our previous work, we optimized compliance of modular trusses [1] via a concurrent method based on meta-heuristics (operating at the module scale) and a conic program (generating optimal module topologies). Here, we present a computationally more attractive sequential strategy applicable to non-convex module design problems including continuum topology optimization of reusable structures and compliant mechanisms.

Our strategy starts from a solution to the free-material optimization problem at the product scale, which we enhance to suppress emerging checkerboard patterns. Subsequently, we develop a novel deterministic clustering algorithm to partition the optimized elasticity tensors into a specified number of clusters while maintaining symmetries in the dataset. We interpret the clusters within the Wang tiling formalism, providing efficient assembly plans with a tunable number of module interfaces. Finally, we optimize the modules with a single-scale topology optimization whose design space is reduced due to modularity.

We illustrate the method efficiency on several problems, including modular structural and compliant mechanism designs together with module reusability.

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