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Descriptor-Based Inverse Design of Periodic Truss Lattices under Impact Loading

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Periodic truss lattices are increasingly considered for lightweight impact-mitigation applications because their macroscopic mechanical response can be tailored through a limited set of geometric parameters. However, their practical design presents two main issues: the computational cost required to generate large and consistent simulation datasets, and the difficulty of solving the inverse problem, namely identifying the unit-cell parameters that yield a target structural response. In this work, an automated framework is presented for the generation of simulation-ready datasets and for the inverse design of periodic truss lattices under dynamic compression. The workflow is implemented in MATLAB and integrates parametric geometry generation, finite-element model export, automated post-processing of stress–strain curves, and training of a Unit-cell Optimization Network (UON). The study focuses on Kelvin and octagonal periodic lattices, for which the mechanical response is reduced to four descriptors: initial stiffness, plateau stress, densification strain, and absorbed energy. These quantities are then used as inputs to a mixed inverse-design model combining regression for strut thickness and classification for unit-cell size. The generated dataset showed clear and physically meaningful trends across the sampled design space, confirming the suitability of the adopted descriptors for learning-based inverse design. After automated cleaning, 1580 valid simulations were retained for training and evaluation. Overall, the results demonstrate that the proposed framework provides a scalable and reproducible strategy for the inverse design of periodic lattice metamaterials, significantly reducing manual intervention while enabling accurate recovery of unit-cell parameters from target mechanical performance.

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