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Abstract

Inverse multi-objective design of heterogeneous cellular structures

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Architected lattice structures, featuring multiple sub-elements arranged in deliberate patterns, can achieve a notably wider array of properties than their uniform counterparts. Traditional design methods for these materials typically depend on expert knowledge and require considerable trial and error effort.

Here, we introduce a data-efficient approach for optimizing 3D-printed architected structures combining two distinct unit cell topologies. This approach uses a framework pairing a Deep Neural Network (DNN) with a Genetic Algorithm (GA), supported by finite element method (FEM) simulations to inverse design heterogeneous lattice structures with tailored elastic modulus and energy absorption efficiency at a low weight.

We specifically apply this method to orthopedic implant design, as a case study to offer structures with biocompatible elastic modulus, and enhanced energy absorption efficiency. Our approach thus provides a data-efficient model for the rapid and intelligent design of architected materials with site-specific customized mechanical and physical properties with a high potential to be used for biomedical implants.

Author's statement

Conflict of interest: The authors declare that there are no conflicts of interest regarding the publication of this research. Informed consent: Informed consent has been obtained from all individuals included in this study.

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