Inverse designing surface curvatures by deep learning

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Abstract

Smooth and curved microstructural topologies found in nature – from soap films to trabecular bone – have inspired several mimetic design spaces for architected metamaterials and bio-scaffolds. However, the design approaches so far have been ad hoc, raising the challenge: how to systematically and efficiently inverse design such artificial microstructures with targeted topological features? Here, we explore surface curvature as a design modality and present a deep learning framework to produce topologies with as-desired curvature profiles. The inverse design framework can generalize to diverse topological features such as tubular, membranous, and particulate features. Moreover, we demonstrate successful generalization beyond both the design and data space by inverse designing topologies that mimic the curvature profile of trabecular bone, spinodoid topologies, and periodic nodal surfaces for application in bio-scaffolds and implants. Lastly, curvature and mechanics are bridged by showing how topological curvature can be designed to promote mechanically beneficial stretching-dominated deformation over bending-dominated deformation.

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