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Designing complex architected materials with generative adversarial networks

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Architected materials on length scales from nanometers to meters are desirable for diverse applications. Recent advances in additive manufacturing have made mass production of complex architected materials technologically and economically feasible. Existing architecture design approaches such as bioinspiration, Edisonian, and optimization, however, generally rely on experienced designers' prior knowledge, limiting broad applications of architected materials. Particularly challenging is designing architected materials with extreme properties, such as the Hashin-Shtrikman upper bounds on isotropic elasticity in an experiencefree manner without prior knowledge. Here, we present an experience-free and systematic approach for the design of complex architected materials with generative adversarial networks. The networks are trained using simulation data from millions of randomly generated architectures categorized based on different crystallographic symmetries. We demonstrate modeling and experimental results of more than 400 two-dimensional architectures that approach the Hashin-Shtrikman upper bounds on isotropic elastic stiffness with porosities from 0.05 to 0.75.