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# Automated discovery of reprogrammable nonlinear dynamic metamaterials

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## Abstract

Harnessing the rich nonlinear dynamics of highly deformable materials has the potential to unlock the next generation of functional smart materials and devices. However, unlocking such potential requires effective strategies to spatially engineer material architectures within the nonlinear dynamic regime. Here we present an inverse-design framework to discover flexible mechanical metamaterials with a target nonlinear dynamic response. The desired dynamic task is encoded via optimal tuning of the full-scale metamaterial geometry through an inverse-design approach powered by a fully differentiable simulation environment. By deploying such a strategy, mechanical metamaterials are tailored for energy focusing, energy splitting, dynamic protection and nonlinear motion conversion. Furthermore, our design framework can be expanded to automatically discover reprogrammable architectures capable of switching between different dynamic tasks. For instance, we encode two strongly competing tasks- energy focusing and dynamic protection-within a single architecture, using static precompression to switch between these behaviours. The discovered designs are physically realized and experimentally tested, demonstrating the robustness of the engineered tasks. Our approach opens an untapped avenue towards designer materials with tailored robotic-like reprogrammable functionalities.

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