

One Structure, Millions of Configurations: Programmable Mechanical Properties via Elastic Rod Origami

Researchers at Stanford have developed Elastic Rod Origami (RodOri), a new class of mechanical structures that can be physically reconfigured into many different shapes, each with distinct and precisely controlled mechanical properties.

Most reconfigurable structures today can only switch between two stable states, limiting how much their properties can be tuned. This severely restricts their usefulness in applications that require adaptive or multi-functional behavior.

RodOri uses simple, curved elastic rods that snap between stable shapes when compressed or twisted, with stiffness precisely controlled by tuning each rod's curvature during fabrication. A single six-rod unit holds up to 11 distinct stable shapes, and a seven-unit assembly can access nearly 20 million unique structural states. This allows on-demand vibration filtering, mechanical signal routing, and stiffness changes of more than 3x. All components are 3D-printed from standard materials, keeping fabrication simple and low-cost.

Stage of development

Proof of concept

Applications

- Adaptive vibration isolation and damping systems for aerospace, automotive, or industrial use
- Reconfigurable mechanical metamaterials for wave-based signal routing and filtering

- Deployable or reconfigurable medical devices such as endovascular implants or stents

Advantages

- Far greater configurational richness than conventional origami or bistable systems: up to 11 stable states per unit vs. 2 for typical bistable elements
- Stiffness tunable by more than 3x across configurations within a single structure
- Simple, low-cost fabrication using standard 3D printing with no complex hinges or actuators required

Publications

- Leanza, S., Lee, J., & Zhao, R. R. (2025). [Elastic Rod Origami \(RodOri\) for Programming Static and Dynamic Mechanical Properties](#) arXiv preprint, submitted August 2025.

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