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REPROGRAMMABLE HYBRID CURVED-STRAIGHT ORIGAMI

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ABSTRACT

Existing origami tessellations typically form curved structural surfaces that cannot remorph into other rigid shapes, or 3D lattices whose stiffness tuning relies on significant size variations, causing abrupt changes in stiffness and affecting properties such as relative density and Poisson's ratio. Here, we present a reprogrammable origami tessellation that integrates curved and straight bistable creases to overcome these challenges: achieving rigidity while enabling reversible remorphability into numerous load-bearing shapes and generating size-invariant 3D lattices with continuously tunable stiffness. We leverage curved-crease origami theories and differential geometry to construct the folded geometry and derive its geometric mechanics. Experiments with paperboard prototypes validate our theory and quantify mechanical performance. By selectively activating or deactivating bistable creases, we demonstrate local and global stiffness tuning over two orders of magnitude. This adaptability and reprogrammability enable applications across various fields and scales, from haptic feedback devices and soft robotics to medical tools, sensors, deployable shelters, and energy harvesting systems.