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EXPLOITING THE NONLINEAR STIFFNESS OF ORIGAMI TO ENHANCE JUMPING MECHANISM PERFORMANCE

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This research investigates the use of origami folding techniques to develop an optimized nonlinear jumping mechanism. A previous theoretical investigation has shown the benefits of using a nonlinear spring element compared to a linear spring for improving the dynamic performance of a jumper. This study sets out to experimentally verify these theoretical results. The Tachi-Miura Polyhedron (TMP) origami structure was used as the spring element connecting two end-point masses. The TMP bellow was optimized to improve air time and maximum jumping height by exhibiting a “strain-softening” nonlinear force-displacement response for increased energy storage. An additional TMP structure was designed to exhibit a close-to-linear force-displacement response to serve as the representative linear spring element. A critical challenge in this study is to minimize the hysteresis and energy loss of TMP during its compression stage before jumping. To this end, we used a concept known as plastically annealed lamina emergent origami (PALEO) to modify the creases of the structure in order to reduce hysteresis during the compression cycle. PALEO works by increasing the folding limit before plastic deformation occurs, thus improving the energy retention of the structure. Steel shim stock was secured to the facets of the TMP structure to serve as end-point masses, and the air time and jumping height of both structures were measured and compared. The nonlinear TMP structure achieved roughly 10% improvement in air time and a 14% improvement in jumping height when compared to the linear TMP structure. These results validate the theoretical benefits of a nonlinear jumping mechanism and can lead to improved performance in dynamic systems which rely on springs as a method of energy storage.

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