

Bioinspired anisotropic Microspines enable agile Robots' control-efficient Disturbance Rejection

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Nature-inspired soft robotic materials increasingly facilitate capabilities ranging from dexterous manipulation to multi-modal locomotion. Inspired by Pel's scaly-tailed flying squirrel—a highly arboreal West African mammal — we translate scans of its caudal scaly organ to reconstruct histology into anisotropic micro-scale arrays, showing how biomimetic materials enhance traction-enhancing performance in scansorial locomotion including climbing with potential for perching. Morphological computation not only increases locomotion robustness but can also simplify control. Directional 1 degree of freedom features provide friction anisotropy, passive energy dissipation, and load-activated interlocking that stabilize contact on uncertain substrates, reducing sensing/actuation demands during climbing and perching. This work combines scalable multi-material additive manufacturing with machine learning-guided inverse design to tune tilt, pitch, and hierarchy for targets such as slip-onset angle, impact energy attenuation and control-effort reduction. Prototypes for soft robotic limbs are inspired by original discovery on model systems in distantly related arboreal specialists, and are realized with multi-scale fabrication techniques, resulting in traction-enhancing structured surfaces.