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PROCEEDINGS

Scale-Inspired Programmable Robotic Structures with Concurrent Shape Morphing and Stiffness Variation

Tianyu Chen[1] and Yifan Wang[1,*]

[1]School of Mechanical and Aerospace Engineering, Nanyang Technological University, 50 Nanyang Avenue, 639798, Singapore

[*]Corresponding Author: Yifan Wang. Email: yifan.wang@ntu.edu.sg

ABSTRACT

Biological organisms often possess remarkable multifunctionality through intricate structures, such as the concurrent shape-morphing and stiffness-variation in octopus. Soft robots, which are inspired by natural creatures, usually require the integration of separate modules to achieve these various functions. As a result, the whole structure is cumbersome and the control system is complex, often involving multiple control loops to finish the required task. Here, inspired by the scaly creatures in nature such as pangolins and fish, we develop a robotic structure that can vary stiffness and change shape simultaneously in a highly-integrated compact body. The scale-inspired layered structure (SAILS) is enabled by the inversely designed programmable surface patterns of the scales. After fabrication, the SAILS is inherently soft and flexible. When sealed in an elastic envelope and subjected to negative confining pressure, it transitions to its designated shape and becomes stiff concurrently. Notably, the SAILS can be actuated at frequencies as high as 5 Hz and achieves an apparent bending modulus change of up to 53 times between its soft and stiff states. We further demonstrate the versatility of the SAILS by developing a soft robot that is amphibious and adaptive, as well as tunable landing systems for drones with the capacity to accommodate different loads.

KEYWORDS

Bioinspiration; variable stiffness; shape morphing; soft robot

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