Soft Robotic Origami Structures: Highly Deformable and Configurable Soft Robots

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Deployable and configurable structures with initial compactness have high potentials for robotic applications [1]. The focus of this project is on an investigation into the possible benefits achievable by applying the deployable origami structural design of soft robots to utilize two different morphing principles. Here, we present soft robots inspired by origami structures that are highly deformable with configurable motions beyond origami kinematics.

I. Soft Robotic Origami Structures

Overview:

We developed soft robotic origami structures that are deformable more than 10 times their initial length with sequencial motion. The structures' geometries were inspired by famous existing deployable origami structures, Miura-ori pattern (Fig.1 A) and Yoshimura pattern (Fig.1 B), and were entirely made of soft and stretchable elastomers. Because the morphing principles of the origami (deformation by rigid translations and rotations, geometry dependent) and soft robot (deformation by straining, material dependent) are different, the initially compact structures behave pseudo-sequential motion. Driven by fluids, the soft robotic origami structures initially morph along the origami structures' kinematics (origami-like motion) and then create anisotropic motions after full-deployment (soft robotic motion, e.g. bending). The configuration of soft robotic motions was designed by giving stiffness difference between facets for asymmetric lengthening. Two different elastomers with different elastic moduli were used for the soft actuator. Some facets of the actuator were made of an elastomer with a low elastic modulus (Dragon skin 10, shore harness A10, Smooth-on) while the other facets of the actuator were made with an elastomer with a high elastic modulus (Dragon skin 30, shore hardness A30, Smooth-on). A systematic study of design parameters associated with both geometry (geometry of crease lines and facets) and materials (material stiffness and patterning) were also conducted.

Demonstrations: On the basis of the proposed deployable architecture, a variety of soft robotic applications become possible with highly compact designs and additional functionalities. We developed typical applications of soft robotic grippers, crawlers, and human-interactive robots, all of which are initially compact as a folded design and then transform to functional soft robots.

For the live-demonstration, we will present two different kinds of soft robotic origami structures, Miura-ori soft robotic origami and Yoshimura soft robotic origami. For Miura-ori soft robotic origami structures, we will demonstrate a various configuration of their origami-like motion and soft robotic motion (e.g. inner bending structure, outer bending structure, S-shape structure). We will also demonstrate some soft robotic applications including crawler and Yoshimura soft robotic origami gripper.

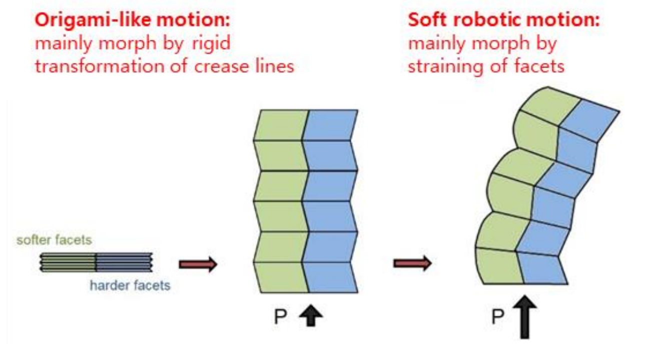

Figure 1. Principle of soft robotic origami structure. The structure deploys by origami-like motion

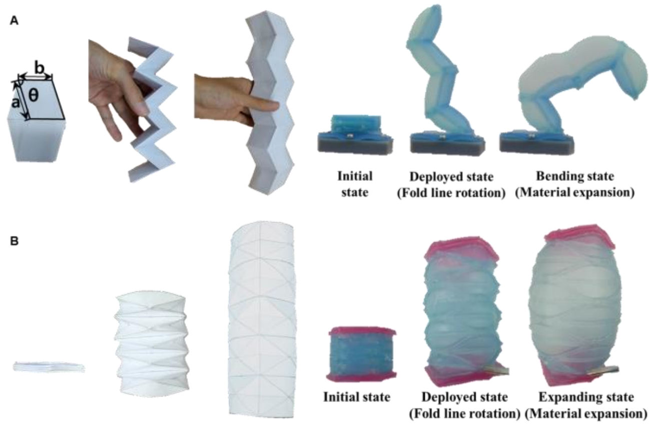

Figure 2. (A) Miura-ori polyhedron inspired soft robotic origami structure. (B) Yoshimura patterned cylinder inspired soft robotic origami structure. Both structures has sequencial motions: origami-like motion and soft robotic motion.

References

[1] S.-J. Kim, et al, "An origami-inspired, self-locking robotic arm that can be folded flat," Science Robotics, vol. 3, no. 16, 2018

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