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Kresling Origami based Haptic Device for Normal and Torsional Cutaneous Feedback

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***Abstract*—Transferring accurate tactile sense via haptic feedback can enhance the accuracy of gripping tasks in teleoperation. This work presents a compact haptic actuator that transfers normal and torsional haptic feedback by utilizing a Kresling origami structure. The device is compact and multi-degree-of-freedom compared to prior haptic systems.**

***Index Terms*—Haptic Device, Cutaneous Feedback, Teleoperation, Kresling**

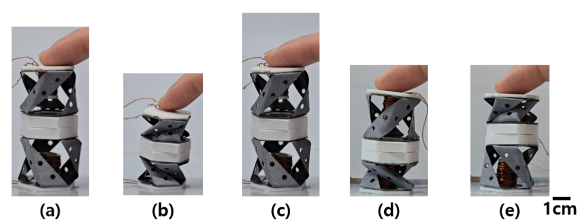
I. Introduction

Gripping is one of the most frequent tasks in teleoperation. Excessive gripping force may damage an object, while insufficient gripping force causes an object to slip. Transferring accurate tactile sensations by haptic feedback can enhance the accuracy and reliability of the gripping task. This work presents a compact haptic actuator that transfers normal and torsional directional feedback using a Kresling Origami structure. Previous origami-based devices lacked miniaturization[1], while voice-coil-based actuators can deliver only vibration-based haptic feedback, which limits the range of modality[2]. A miniaturized origami-based structure and integrated electromagnetic actuators enable a compact design and deliver realistic haptic feedback.

II. Working principle, Experiments

The core mechanism of our device is based on the Kresling origami structure, in which normal and torsional motions are coupled. The overall base of the device is constructed using ripstop cloth for flexibility and durability. A 200μm thick fiber-reinforced polymer (FRP) plate is attached with heat adhesive (HeatnBond) to reinforce rigidity. Since normal and torsional motions are coupled in a single Kresling, two chiral Kresling structures are connected in series for independent control. The electromagnetic actuator is composed of a neodymium magnet and a solenoid. The overall device is shown in Fig. 1(a), and the fundamental actuation modes of our device are illustrated in Fig. 1(b)–(e).

To validate the motion capability of our device, camera-based displacement measurements confirmed normal and torsional displacements, as demonstrated in the accompanying video. The device achieved up to 12.9 mm of normal displacement and 50° of rotation. Force sensing further confirmed that up to 0.7 N of normal force was transferred to the users.



Top	(a) neutral	(b) Compression	(c) Expansion	(d) Expansion	(e) Compression
Bottom	Neutral	Compression	Expansion	Compression	Expansion
Movement	Neutral	Normal Compression	Normal Expansion	CW rotation	CCW rotation

Fig. 1. Fundamental actuation modes of Kresling dipole

III. Conclusion

This work presents a compact haptic device capable of delivering both normal and torsional feedback using a Kresling origami structure. While the device successfully demonstrates the generation of multi-directional haptic outputs, future work will focus on improving rendering precision and conducting a user study to evaluate perceptual effectiveness and usability.

References

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