ICCES, 2024, vol.30, no.3
DOI: 10.32604/icces.2024.011746

PROCEEDINGS

Miura-Origami Soft Robots with Proprioceptive and Interactive Sensing via Embedded Optical Sensors

Shaowu Tang[1], Sicong Liu[1,*] and Jian S Dai[1,*]

[1]The Department of Mechanical and Energy Engineering, Southern University of Science and Technology, Shenzhen, 518055, China

[*]Corresponding Author: Sicong Liu; Jian S Dai. Email: liusc@sustech.edu.cn; jian.dai@kcl.ac.uk

ABSTRACT

Origami, a traditional and elegant folding technique, provides a solution for the deformation of three-dimensional structures. Inspired by this, origami-based soft actuators and robots exhibit the advantages of portability, high efficiency, and programmability when performing functions such as locomotion, manipulation, and interaction. However, these deformable origami structures bring challenges to sensing methods and technologies, due to hyperelastic deformations of the soft materials. In this work, a sensing approach is proposed to enable origami robots with proprioceptive and interactive sensing capabilities. The 3D-printed Miura-ori chambers of the robot are embedded with infrared optical sensors (a light-emitting diode and a photodiode), while the kinematics model of deformable Miura-chamber and the transmission model of light are established. The rationality and accuracy of these models are verified through systematic experiments and finite element simulations. The relationship between the state of origami unit and sensing signal is obtained to achieve multimodal perception. For applications, based on the modular combinations of Miura-ori and embedded optical sensor units, we build a crawling robot, a soft arm, and a flexible metamaterial sensor, which are fabricated through 3D-printing method using thermoplastic polyurethane (TPU) soft material. Experimental results and demonstrations further show the generalizability of the proposed sensing approach, paving the way to the innovation on sensing methods of soft origami robots.

KEYWORDS

Miura-ori structure; soft robotics; 3D printing; optical sensing

Funding Statement: This work was partly supported by the National Key R&D Program of China (Grant No. 2022YFB4701200), Shenzhen Science and Technology Program Grant JCYJ20220530114615034 and JCYJ20220818100417038, Guangdong Basic and Applied Basic Research Foundation Grant 2021A1515110658.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.