2014 IEEE International Conference on Robotics & Automation (ICRA)
Hong Kong Convention and Exhibition Center
May 31 - June 7, 2014. Hong Kong, China

Fabrication of Origami Wheel using Pattern Embedded Fabric and its Application to a Deformable Mobile Robot

Dae-Young Lee, Ji-Suk Kim, Jae-Jun Park, Sa-Reum Kim and Kyu-Jin Cho, *Member, IEEE*

***Abstract*— The unique characteristics of origami to realize 3-D shape from 2-D patterns have been fascinating many researchers and engineers. This paper presents a fabrication of origami patterned fabric wheels that can deform and change the radius of the wheels. PVC segments are enclosed in the fabrics to build a tough and foldable structure. A special cable driven mechanism was designed to allow the wheels to deform while rotating. A mobile robot with two origami wheels has been built and tested to show that it can deform its wheels to overcome various obstacles.**

I. Introduction

In this paper, we present a deformable wheel robot based on origami structure wheels. Origami means the traditional Japanese art of paper folding. The unique characteristic of origami to realize 3-D shape from 2-D patterns has been fascinating many researchers and engineers [1]. In prior research, the author used an origami structure as a special kind of morphing structure [2, 3]. The main part of the wheel, a complex jointed 3D surface can be created by simple 2D fabrication method composed of rigid and flexible layers. Moreover, the movement of the whole structure was constrained by structural characteristics, and it makes easy to control the wheel shape.

II. Wheel Pattern Design

The origami pattern for the wheel was made by using a well-known origami pattern, the magic ball pattern. To use this design to make a wheel, a specially designed magic ball pattern with added spokes was devised. Because of its structural characteristics, the whole structure can be changed by actuating only a small portion of the wheel.

III. Fabrication of Wheel Structure

For wheel fabrication, a pattern embedded fabric was designed to make a robust but foldable structure. This structure is composed of fabric, adhesive layer, and P.V.C. segments. The P.V.C segments are enclosed with fabric and the stitches are sewn around them, so it is possible to achieve tough and foldable structure. Additionally, because of the tough skin of the wheel, it is possible to attach steel hooks on the skin, and it highly increases the robot's climbing ability.

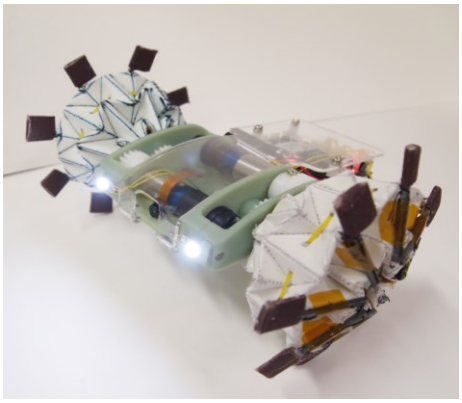

Figure 1. Origami Wheel Robot.

IV. Deformation Mechanism Design

The wheel deformation mechanism was composed of a D.C. geared motor, sliding shaft and cable. When the motor pulls the wire, the wheel diameter becomes larger. Also there is a rubber band around the wheel, so the wheel returns to the original shape when the motor unwinds the wire. The total weight of the robot is about 470 g and the wheel diameter can deform from 55 mm to 120 mm (with the hook). The maximum speed of the robot is about 0.3 m/s

V. Conclusion

Using the fabrication method and the mechanisms presented in this paper, the origami wheel robot was made as shown in Fig. 1. The fabric provides enough toughness as a wheel in both deformed and undeformed states, and the geared DC motor enables fast and robust deformation of the wheel. In future work, quantitative analysis of deformation will be conducted and various materials will be utilized for robust and foldable structures.

*Resrach supported by the National Research Foundation of Korea (NRF) (No. 2012-0000348) and the Asian Office of Aerospace Research and Development (AOARD) (No. FA2386-13-1-4019).

D. Lee, J. Kim, J. Park, S. Kim are with School of Mechanical and Aerospace Engineering, Seoul National University, Gwanak-ro, Gwanak-gu, Seoul 151-742, Korea (e-mail: winter2nf@gmail. com; rubagi05@gmail.com; pjunyyy@hanmail.com; sareumkim1@gmail.com)

K. Cho is with School of Mechanical and Aerospace Engineering, Seoul National University, Gwanak-ro, Gwanak-gu, Seoul 151-742, Korea (phone: +82-2-880-1663; fax: +82-2-880-1663; e-mail: kjcho@snu.ac.kr)

References

[1] D. Dureisseix, "An Overview of Mechanisms and Patterns with Origami", International Journal of Space Structures, Vol. 27, No. 1, pp 1–14, 2012.

[2] Dae-Young Lee, Gwang-Pil Jung, Min-Ki. Sin, Sung-Hoon Ahn and Kyu-Jin Cho, "Deformable Wheel Robot Based on Origami Structure," Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), pp. 5592-5597, 2013

[3] Dae-Young Lee, Ji-Suk Kim, Sa-Reum Kim, Je-Sung Koh, Kyu-Jin Cho, "The Deformable Wheel Robot using Magic-Ball Origami Structure", Proceedings of the ASME 2013 IDETC/CIE.