

Real-time Shape Sensing with Computational Mechanics

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Introduction

□ Shape sensing:

- Measurement of 3D morphology change
- Target applications include wearable devices, surgical robots and rehabilitation robots

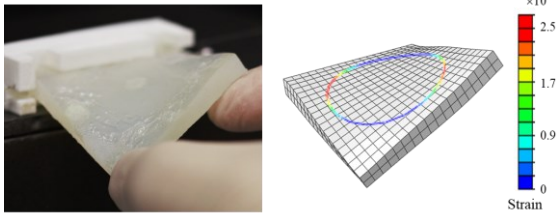
□ Data-driven Computational mechanics:

- Sensor parameters analysis
- Data enrichment for model training
- Computational mechanics + Machine learning

Method

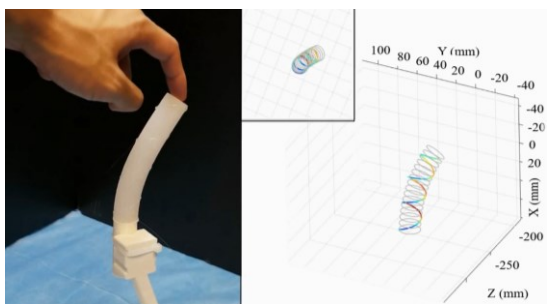
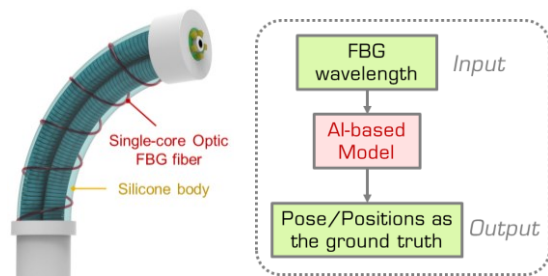
□ Surface shape reconstruction:

- Finite Element (FE) simulation enriches morphological information [1].
- Displacement estimated by artificial neural networks (ANN).



□ Shape sensing for tube-shaped structure:

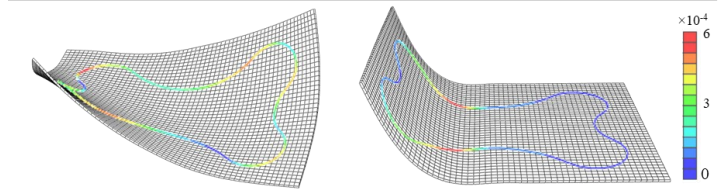
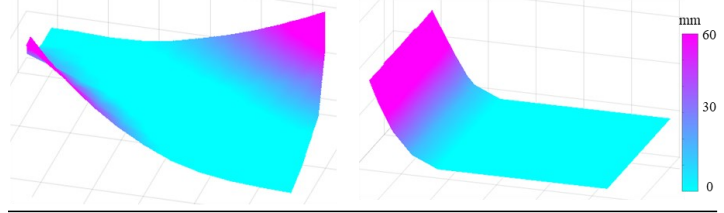
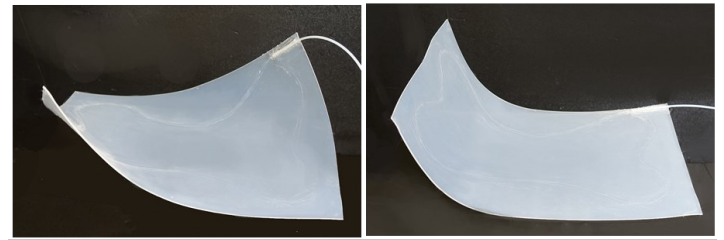
- Optical fiber helically wrapped along a spring-reinforced soft continuum [2].
- Closed-loop control for soft and flexible robots.



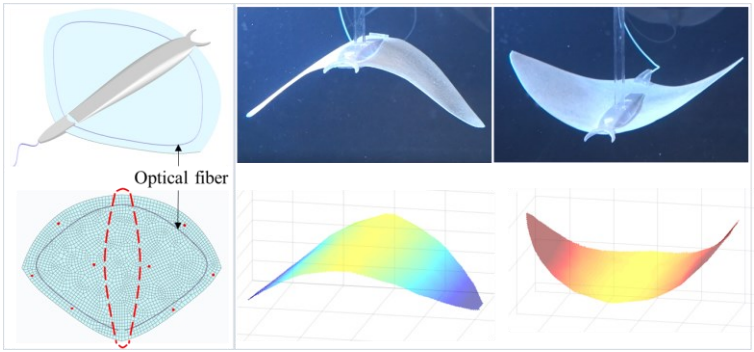
Results

□ Large-scale (1mm A4-size) surface shape sensing [3]:

- High accuracy (RMSe = 2.28mm) , update frequency of 100 Hz.



□ Shape sensing of manta ray fin:



Discussion

- Real-time shape sensing for high-performance soft robot modelling and control.
- Online learning-based pose estimation using sparse strain measurement of single-core FBG fiber and sensing fusion with mono-camera SLAM.
- Learning-based morphology modelling approach using FE-enriched data, which enables application-focused customization and production.

References

- [1] Lun, T. L. T., et al. "Real-Time Surface Shape Sensing for Soft and Flexible Structures Using Fiber Bragg Gratings." IEEE RA_L, 4.2 (2019): 1454-1461.
- [2] Wang, X., et al. "Eye-in-hand visual servoing enhanced with sparse strain measurement for soft continuum robots." IEEE RA_L, 5.2 (2020): 2161-2168.
- [3] Wang, K., et al. "Large-scale surface shape sensing with learning-based computational mechanics." AISY, (under review).

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