结的妙用——让光纤赋予机器人指尖触觉感知

DOI: 10.12086/oee.2024.241009.h02

对机器人而言，对摩擦和滑动的精准感知在各种精细操作中起着至关重要的作用。与传统的刚性梁式三维力传感器不同，柔性三维力传感器尚处于研究阶段，普遍面临传感系统复杂、解耦难度大、一致性欠佳等问题。

受到纽结结构的启发，之江实验室类人感知研究中心团队提出了将聚合物光纤打结构成柔性三维力传感结构的构想。纽结的立体结构打破了光纤原本的圆对称结构，调整了光纤表面的载荷分布，使得由单根光纤构成的传感单元能够对不同方向的力刺激产生特异性响应，为构建三维力传感器提供了新思路。

该工作分析验证了聚合物光纤结对方向力的特异性响应能力，并在此基础上，设计制作了光纤结阵列，成功实现了三维力测量。通过将传感器集成在两指机械手指腹处采集摩擦、滑动等触觉信息，辅助机器人完成抓取物体、使用工具等灵巧操作。

该工作首次将聚合物光纤结应用于三维力传感，系统分析了纽结三维结构对光纤所受载荷的再分配特点，充分展示了由此带来的压力、切向力传感特性，从而进一步降低了系统复杂度以及信号解耦的运算难度。构成光纤结传感器的聚合物光纤既是传感元件，也是信号的传输通道。

Opto-Electronic Advances, 2023, **6**(10): 230076.
https://www.oejournal.org/article/doi/10.29026/oea.2023.230076.

The magic of knots: Harnessing optical fibers for tactile sensing in robotics

DOI: 10.12086/oee.2024.241009.h02

Drawing inspiration from knots, an interesting idea presents itself - polymer optical fiber knots. The knot's three-dimensional structure breaks the fiber's original circular symmetry, redistributing the load on the fiber surface. In turn, this empowers individual fiber units to respond uniquely to force stimuli from different directions, promising the creation of intricate 3D force sensing devices.

The research team from the Research Center for Humanoid Sensing in Zhejiang Laba introduces a new strategy in the construction of 3D force sensors through the combination of knots and optical fibers. By analyzing the structure mechanics of the knot, researchers have successfully improved the sensing performance for pressure, friction and slips. This approach simplifies the system complexity and overcomes computational challenges associated with signal decoupling.

Furthermore, the polymer optical fibers not only serve as sensing elements but also act as signal transmission channels. This feature simplifies the signal acquisition process of the sensor array, which is beneficial to system integration. Additionally, a single polymer optical fiber can be used to create multiple fiber knots, allowing for additional functions through the incorporation of functional materials or strategies such as multi-wavelength signal multiplexing.

Opto-Electronic Advances, 2023, **6**(10): 230076.
https://www.oejournal.org/article/doi/10.29026/oea.2023.230076.