仿生设计推动超灵敏光学传感器的研发

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巴西圣埃斯皮里图联邦大学的 Arnaldo Leal-Junior 教授和葡萄牙阿威罗大学的 Carlos Marques 教授研究小组文章提出一种能够超灵敏地探测作用力 (强度和位置) 和方向的仿生多功能柔性光学传感器 (BioMFOS)。该结构的生物灵感来源于球形蛛网，是一种用于捕获猎物和振动传输的多功能设备。这种球形网仿生结构由 3D 打印技术制成，通过加工光敏树脂 (数字光处理) 形成带有球形网框架和辐射振子的结构。接着用聚二甲基硅氧烷 (PDMS) 树脂包裹 3D 打印结构，以创建类似于光纤和波导中纤芯和包层的结构，其中纤芯和包层之间的折射率差异导致在球形网仿生结构中发生全内反射。仿生传感器设备尺寸小 (约 2 厘米)、重量轻 (0.8 克)，适合穿戴应用和服装集成。

BioMFOS 作为光学传感器，其工作原理是基于光信号的变化。将一个微型发光二极管 (μ-LED) 嵌入在球体结构中心的 PDMS 矩阵中，并与两个氧化银电池结合，而球体结构的端部连接到光电探测器 (测量透射光功率) 或光谱仪 (测量每个波长的光功率)。电池不仅用于为系统中的有源元件 (LED 和探测器) 供电，还充当质量块的角色，允许振动、应力和应变在球形网仿生结构中传输。因此，沿着传感器结构施加在不同位置的作用力可以被传输，并在球体结构的每个辐射振子上同时测量，传感器连接着辐射振子，从而实现紧凑型多参数传感器的设计。

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The role of bioinspiration for ultrasensitive optical sensors development

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Since the earliest scientific developments, researchers look to the nature as an inspiration source for the design of novel functional devices. The so-called bioinspiration and biomimetic designs enabled the development of multifunctional sensors.

Recently, the research groups of Prof. Arnaldo Leal-Junior from Federal University of Espírito Santo and Prof. Carlos Marques from University of Aveiro reported the development of an ultrasensitive flexible optical waveguide sensor bioinspired in orb webs, the so-called bioinspired multifunctional flexible optical sensor (BioMFOS).

The multifunctional feature of the structure is achieved by using transparent resins that present both mechanical and optical properties for structural integrity and strain/deflection transmission as well as the optical signal transmission properties with core/cladding configuration of a waveguide. The BioMFOS has small dimensions (around 2 cm) and lightweight (0.8 g), making it suitable for wearable application and clothing integration with an ultra-high sensitivity and resolution, where forces in the μN range can be detected and the location of the applied force can also be detected with a sub-millimeter spatial resolution. The sensor is integrated in clothing for respiration monitoring as well as movement analysis such as trunk and finger positions, depending on the BioMFOS positioning with a correlation coefficient higher than 0.9 when compared with a gold-standard inertial measurement unit.

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