

Biohybrid Humanoid Robots Enable Fiber-Based Bioengineering Sensing: fiber sensors, bio-hybrid humanoid robot platform, digital health.

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ABSTRACT

Fiber-based sensors offer a promising platform for continuous and multimodal physiological monitoring due to their flexibility, scalability, and compatibility with biological tissues. However, their reliable evaluation under dynamic, human-relevant conditions remains a key challenge, limiting translation to digital health applications. Here, we present an integrated bioengineering framework that combines fiber-based bio-sensing systems with biohybrid humanoid robotic platforms for systematic sensor validation and optimization. We develop fiber sensors capable of capturing diverse physiological signals across in vitro and in vivo conditions, including mechanical, electrophysiological, and biochemical cues, with high sensitivity and stability for long-term monitoring. To bridge the gap between laboratory testing and real-world use, we introduce a biohybrid humanoid robotic platform that mimics human biomechanics and physiological responses. This platform enables controllable and reproducible evaluation of sensor performance under realistic motion, deformation, and multimodal stimuli. By integrating sensing and robotic evaluation, we establish a closed-loop framework for sensor design and validation. It provides a new paradigm for fiber-based bioengineering sensing and advances the development of wearable and implantable technologies for continuous, personalized digital health.