Polymer Fiber Bragg Grating-embedded Artificial Skin for Tactile Force Detection and Contact Localization of Robotic Fingers

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Human mechanoreceptors are a reliable guide for many state-of-the-art robotics and sensing technologies in the replication of tactile perception. Perception of pain, although often undesired, provides means of protection from the damaging stimuli, avoiding damages to the body as well as triggering preventive reactions. With fingertips being the localities of highest spatial acuity for touch and pain, it is especially crucial for robotic fingertips or grippers to mimic these sensory perceptions to ensure safe interactions during object manipulation.

Fiber Bragg Gratings (FBGs) are excellent candidates for distributed tactile sensing due to their small size and high multiplexing capabilities in addition to other advantages offered by optical fiber sensors such as immunity to electromagnetic interference, light weight and resilience to moisture and rust. However, conventional silica-based single mode fibers, due to their limited bending radii and tendency to fracture upon bending, face challenges sensing in compact areas, rendering them a less suitable medium of preference for tactile sensing in a confined area such as in robotic fingertips. ZEONEX-based polymer optical fibers are resilient to small curvatures. Furthermore, the lower Young's modulus of these fibers renders ZEONEX-based polymer FBGs low stiffness levels compared to their silica counterparts.

In this study, a silicone-based artificial skin embedded with ZEONEX-based polymer FBGs is designed and fabricated. The artificial skin is integrated with four cascaded ZEONEX-based polymer FBGs, and molded onto a fingertip model in an effort to mimic tactile perceptions of the fingertip. The findings demonstrate that the responses of the embedded FBGs inscribed in a single optical fiber, utilized with a machine learning model aid in contact localization through tactile force feedback.

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