Continuous Deformation Sensing Using Stretchable Optoelectronic Lightguides for Soft Robots

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In recent years, a variety of flexible and stretchable piezoelectric, capacitive, resistive, magnetic, and optical sensors have been developed for measuring deformations within or over soft structures. Many of them are fabricated into 2D sheets or onto the surface of an object to measure the deformations over their surface. While surface deformations can be used to measure the overall shape of a structure, being able to internally measure the shape of the structure while externally measuring interactions with other objects would be ideal. The 2D sensors are great electronic skins but are hard to adapt to the 3D space inside structures (soft or otherwise). Distributed internal sensors would provide important information on local deformations and possibly failures. Of the many types of sensors, optical strain sensors in particular have great properties such as low hysteresis, high sensitivity, linearity, and low cost fabrications, but each sensor can only measure an overall elongation or force applied. To leverage the properties of optical sensors, we created a system of lightguides that interact with each other through frustrated total internal reflection to localize the positions of the deformations. To integrate this system within a soft structure, we stereolithography 3D print a low modulus, polyurethane scaffold through which we thread each lightguide into place. We will demonstrate that our optical sensor array can be used to localize the placement of both internal deformations and external touches.