Inflatable fabric-based robot grasping devices

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Goal

Develop soft sensors to enable proprioception of soft fabric actuators that don't compromise their natural advantages.

Employ soft multipoint waveguide sensor for proprioception and exteroception in inflatable fingers.

Design and fabricate a soft fabric-based inflatable finger with easy sensor integration for bending measurement.

Motivation

Disadvantages of conventional robotic systems include rigidity, multiple moving parts, and the need for elaborate safety precautions in HRI settings.

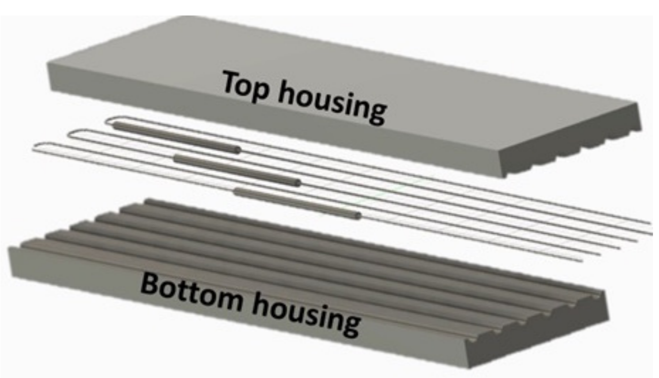
Soft manipulators and grippers are gaining traction as they can handle large payloads whilst being lightweight, compliant, low-cost, and compactible or collapsible.

Perception in soft robotics needs sensors made from soft materials as rigid sensors are not suitable.

Proposed Sensor

The proposed sensor consists of 2 main parts:

- The sensing elements
- The housing



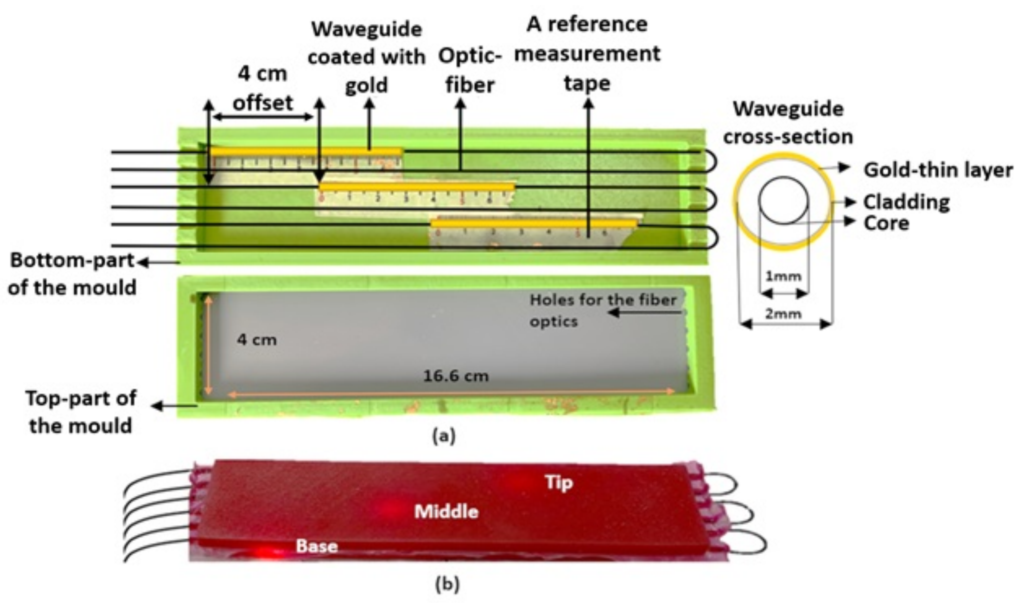
The sensing elements are 3 stretchable optical waveguides that utilise the principle of light intensity modulation.

The waveguides are embedded in a silicone housing.

Sensor Design

a) Waveguide placement inside a 3D printed mould with a 4 cm offset between waveguides. Optical fibres are inserted through 6 apertures made at either end of the mould. Cross-section of a waveguide is shown, revealing inner layers;

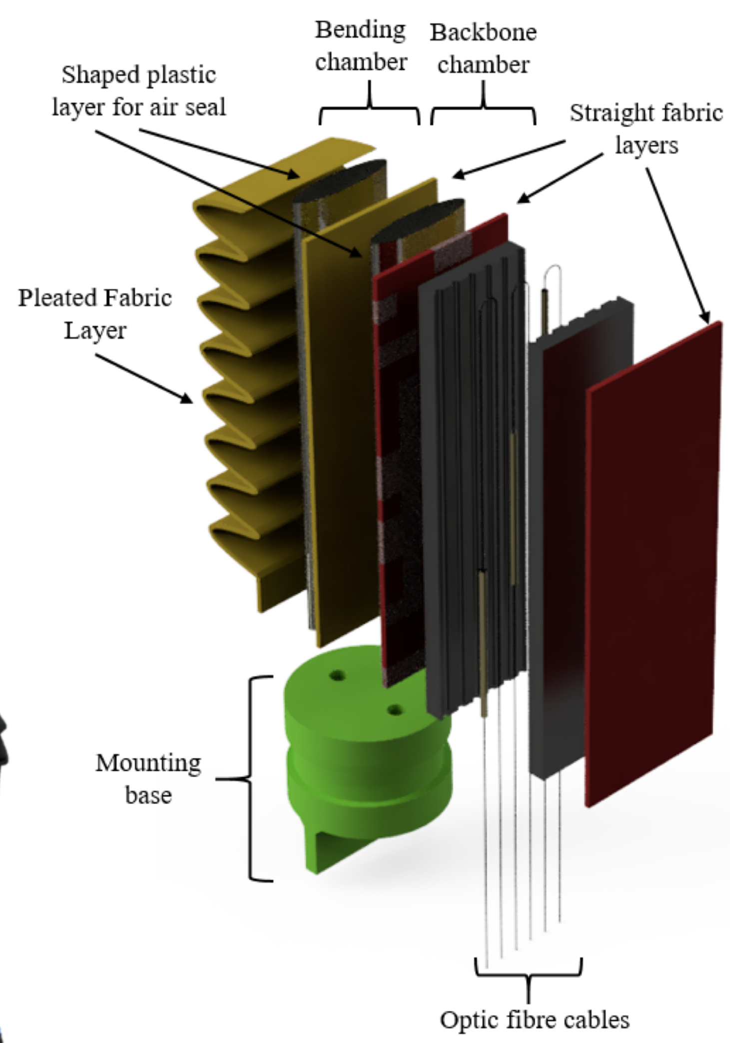
b) Light is transmitted through the 3 integrated waveguides at the base, centre and tip of the sensor structure.



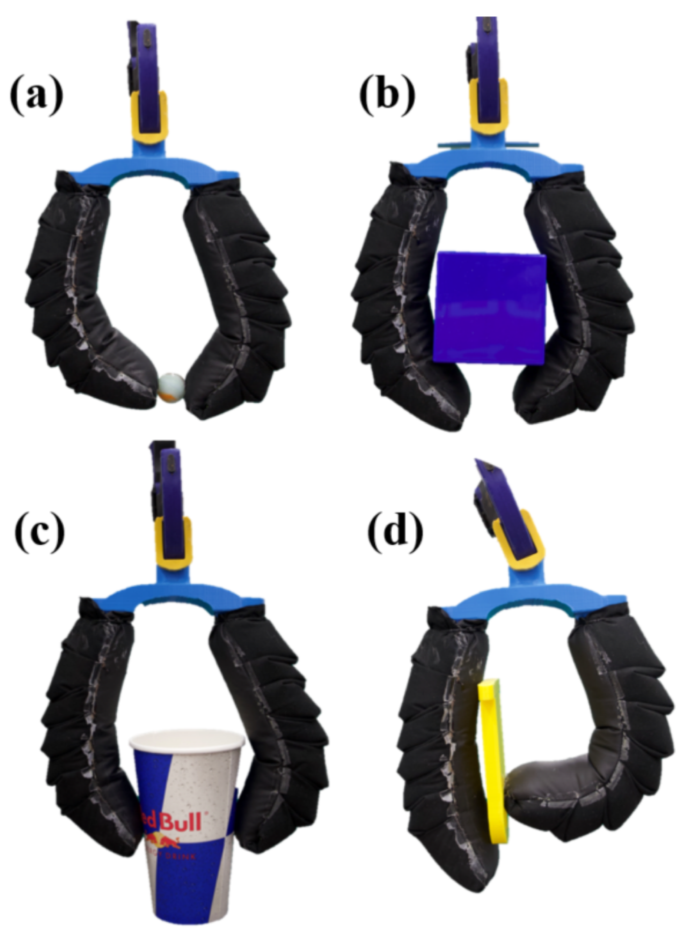
Optical waveguides are secured within bottom mould in a staggered configuration with an offset of 4 cm between each pair.

Soft Fabric-based Pneumatic Actuator

(**top right**) Exploded view of soft fabric-based pneumatic actuator (SFPA) assembly showing actuator structure and optical fibre cables connected to waveguides:



(**below**) 2-fingered actuator holding various objects:



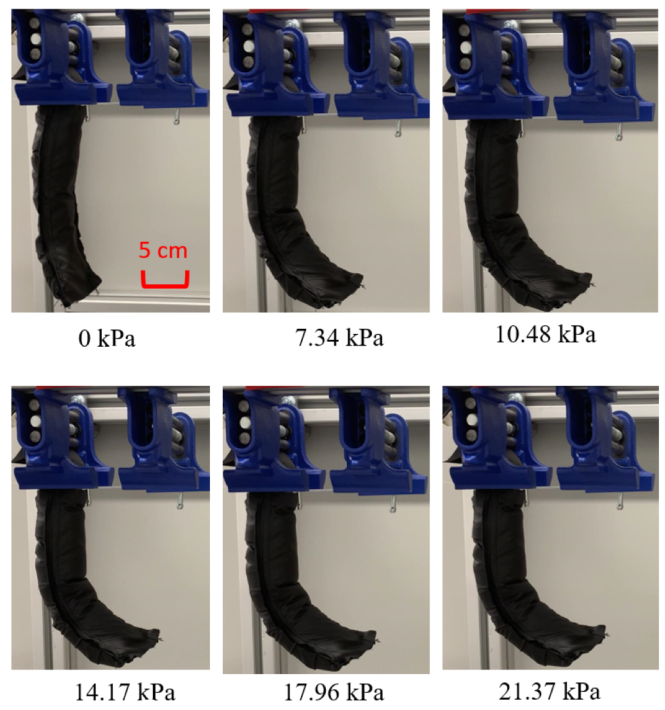
(a) Small marble
(b) Cube
(c) Paper cup
(d) Plastic bracket

Fabric-based robot arms and fingers are predominantly cylindrical structures with folds and pleated structures integrated to achieve bending.

Fabric-based actuators are low-cost and can be manufactured in bulk, via industrial or programmed sewing machines, to generate complex shapes.

Sensorisation of Soft Finger

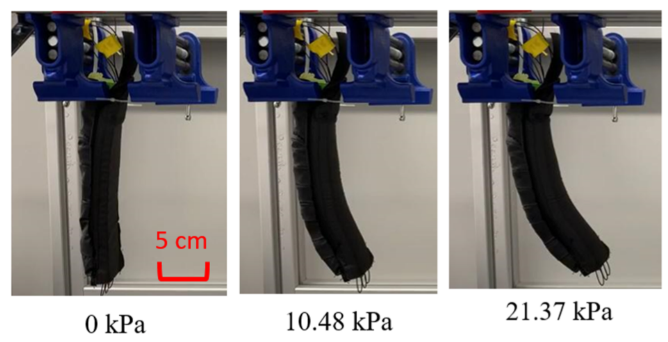
The soft fabric-based finger is first tested without the sensor – to record the curvature response through the bending process due to pressure.



The bending experiment is repeated with the sensor encased in the fabric finger.

As expected, in this experiment the finger does not achieve the same curvature under similar input pressure due to the added weight of the sensor.

The weight of the sensor is 85 g – much greater than that of the finger.



Conclusion

We report on the novel design and fabrication of both a staggered soft optical waveguide sensor and a soft fabric-based finger.

The sensor has good sensitivity and responsiveness during mechanical compression and bending tests.

Adding the sensor obstructs the bending and flexibility of the finger due to the added weight and motion constraints.

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