A modular tactile sensor demonstrated during object grasping

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**MOTIVATION**

As robots enter the social environment, their ability to process their environment must be expanded. One novel solution, being explored on the NASA Robonaut 2 glove, is tactile sensing.

Current tactile sensors often face the following challenges:

- Limited data during object manipulation
- Bulk, high computational and power costs

**SOLUTION & METHOD**

Our tactile sensor provides:

- Rich data during object manipulation
- Low computational and power costs

The sensor is also:

- Small and flexible
- Easily integrated without rewiring
- Surface mountable

**Sensor Components**

The tactile sensor contains:

1. Time-of-flight sensor
2. Barometer
3. Pulse oximeter
4. Accelerometer

**Object Gripping for Sensor Characterization**

We used the sensor during object grasping tasks to demonstrate the applicability of the sensor.

We built a two-finger gripper modeled after the UC Softhand[3]:

1. Flexible scaffold printed from Tough material on the Form2 3D printer
2. The scaffold was cast in Vytaflex 30, a polyurethane elastomer
3. Fingers mounted with a 1501 Power HD Servo to actuate pulleys

**RESULTS**

**Two-Finger Gripper used in Object Grasping**

![Two-Finger Gripper](image)

**Object Grasping Experiments**

<table>
<thead>
<tr>
<th>Object</th>
<th>Unique Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black cloth</td>
<td>Soft and non-reflective</td>
</tr>
<tr>
<td>Sponge</td>
<td>Soft, elastic, porous</td>
</tr>
<tr>
<td>Cardboard</td>
<td>Non-reflective, pliable, flat, large</td>
</tr>
<tr>
<td>Shiny coin</td>
<td>Small, reflective, hard</td>
</tr>
<tr>
<td>Apple</td>
<td>Reflective, soft, firm, large</td>
</tr>
<tr>
<td>Blueberry</td>
<td>Dull, small, soft, round</td>
</tr>
<tr>
<td>Marshmallow</td>
<td>Soft, elastic, round</td>
</tr>
<tr>
<td>Gummybear</td>
<td>Soft, elastic, translucent, small</td>
</tr>
</tbody>
</table>

**Sensor Responses during Grasping**

<table>
<thead>
<tr>
<th>Object</th>
<th>Pressure</th>
<th>ToF</th>
<th>Pulse Ox.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Sponge</td>
<td>✔</td>
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<td>Blueberry</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Pressure readings during manipulation behaved unexpectedly in two ways:

- Decreased upon contact with an object—possible indication of bending
- Amplitude of pressure differential was not correlated with hardness or size of the object

Time-of-flight proximity data behaved as expected:

- Approaching an object, range decreased
- Upon contact, range remained constant
- Releasing an object, range increased

Pulse-oximetry data rendered three signals:

- IR light reflected from every object, with the highest change occurring on the marshmallow
- Red light bounced off of every object to a varying degree, except the black cloth
- Green light did not comparably react on any object, except the gummybear, where all signals were relatively low

**REFERENCES**


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