A modular tactile sensor demonstrated during object grasping

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SML SOFT MACHINES LAB integrated soft materials for human-compatible machines and electronics

MOTIVATION

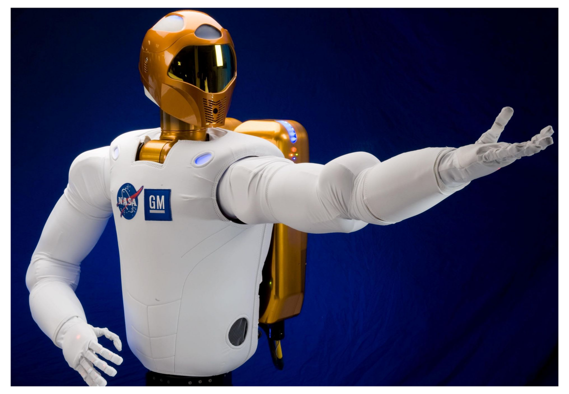

Figure 1. NASA Robonaut 2 [1]

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:[3]

- ➢ 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

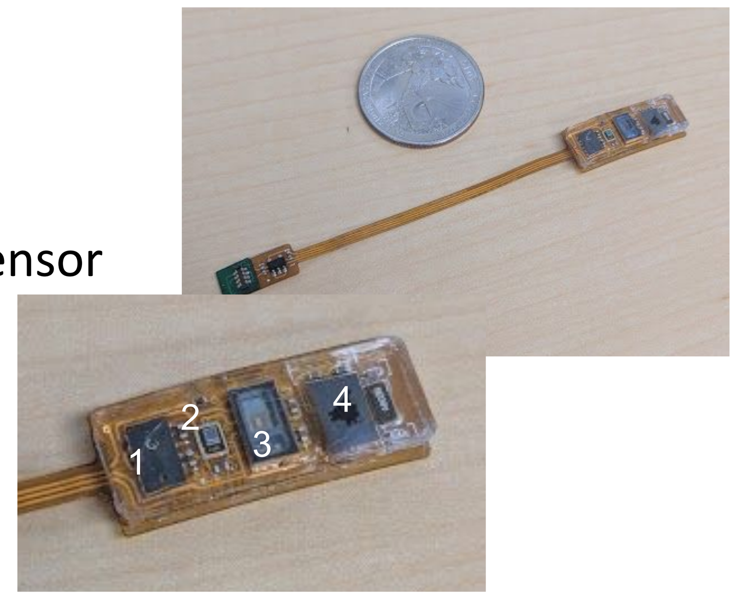

Figure 2. The tactile sensor pictured here. A quarter is included for scale.

Credit to Dr. Eric Markvicka for fabrication of the tactile sensors.

Object Gripping for Sensor Characerization

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

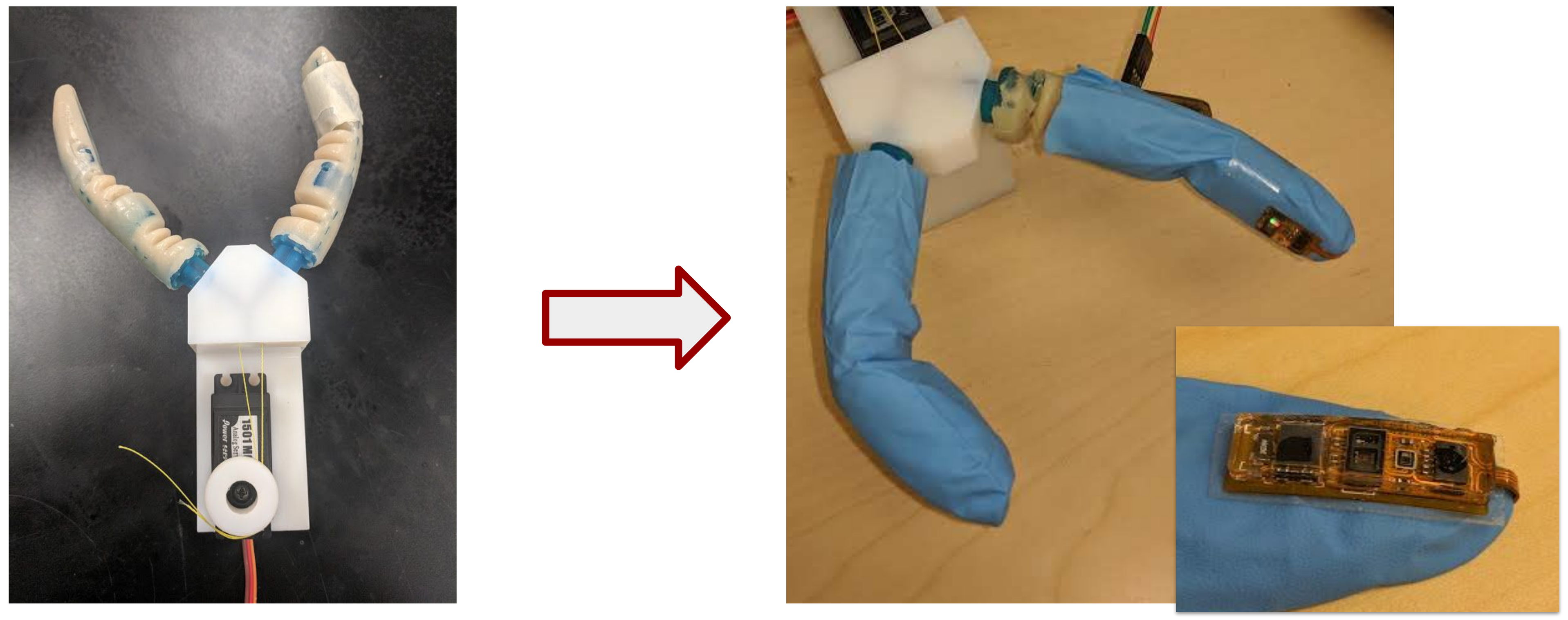

Figure 3. Nitrile gloves were used to aid the adhesion of the tactile sensor to the fingers of the anthropomorphic two-finger gripper.

Object Grasping Experiments

Grasping Experiment Characteristics

Object	Unique Properties
Black cloth	Soft and non-reflective
Sponge	Soft, elastic, porous
Cardboard	Non-reflective, plyable, flat, large
Shiny coin	Small, reflective, hard
Apple	Reflective, soft, firm, large
Blueberry	Dull, small, soft, round
Marshmallow	Soft, elastic, round
Gummybear	Soft, elastic, translucent, small

Table 1. Each object was tested to determine the sensor response to different material properties

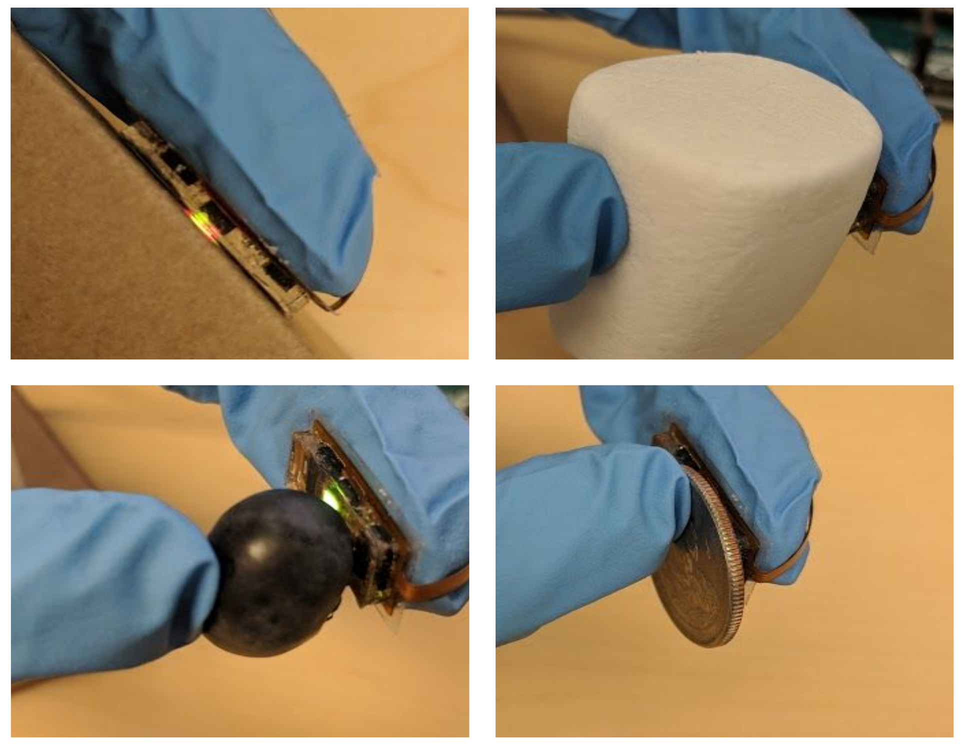

Figure 4. Tactile sensor in action during object grasping. Top-left: cardboard. Top-right: marshmallow. Bottom-left: blueberry. Bottom-right: quarter.

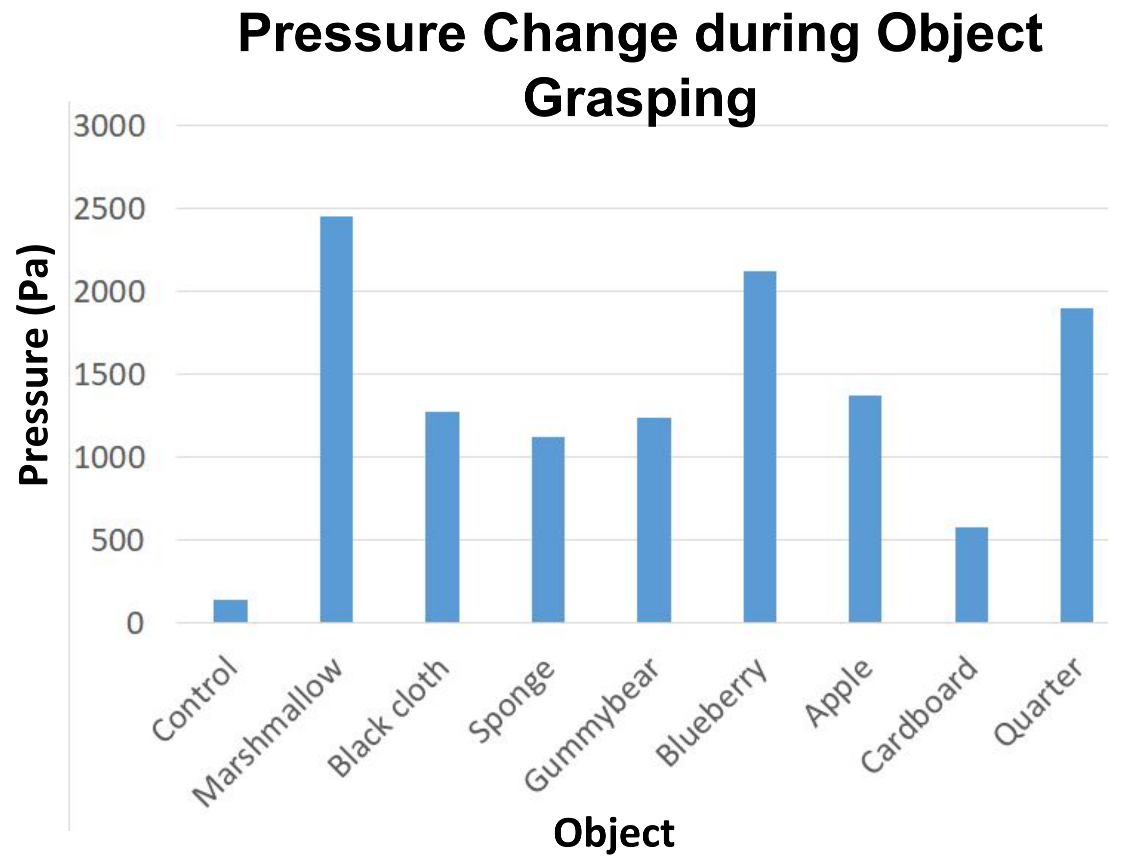

Figure 5. Pressure change during manipulation of different objects

Sensor Responses during Grasping

Object	Pressure	ToF	Pulse Ox.
Cardboard	✖	✔	✔
Sponge	✖	✔	✔
Black cloth	✖	✔	✔
Marshmallow	?	✔	✔
Gummybear	✖	✔	✔
Apple	✖	✔	✔
Shiny coin	?	✔	✔
Blueberry	?	✔	✔

Table 2. The time-of-flight sensor and pulse oximeter rendered predictable and repeatable results. The pressure sensor response did not follow the predicted trend of increased pressure upon contact with harder objects.

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 remaned 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 marshamallow
- ➢ 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

FUTURE WORK

- ➢ Analysis of accelerometer data during slip condition testing
- ➢ Integration with a closed-loop algorithm
- ➢ Demonstration of the sensors used with a dexterous 5-fingered robot hand

REFERENCES

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[2] Z. Kappassov, J. Corrales and V. Perdereau, "Tactile sensing in dexterous robot hands — Review", Robotics and Autonomous Systems, vol. 74, pp. 195-220, 2015.

[3] M. Tavakoli, R. Batista and L. Sgrigna, "The UC Softhand: Light Weight Adaptive Bionic Hand with a Compact Twisted String Actuation System", Actuators, vol. 5, no. 1, p. 1, 2015.

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