Demonstration of the Sensorized RBO Hand 2:
Using Task Knowledge to Efficiently Sensorize Soft Actuators

Vincent Wall  Gabriel Zöller  Oliver Brock

Abstract—Contact with objects and the environment will cause complex deformations in soft hands. While the space of possible deformations of soft hands is very large due to their flexible materials, deformations that actually occur during contact interactions are much more limited. We use this knowledge to add sensors that measure task-relevant deformations. This demo presents the Sensorized RBO Hand 2, capable of measuring three-dimensional deformation of each of its four fingers. This enables it to detect and measure contacts that occur during grasping and manipulation.

I. INTRODUCTION

The compliance of soft robotic hands makes manipulation safer and simplifies control. Contact with objects and the environment causes the soft hands to passively adapt their shape. In order to effectively leverage those contacts and create more robust manipulation strategies, sensorization of the soft hands is required. But the high flexibility of soft hands also means that the space of possible deformations is very large. This makes sensorization of such hands challenging, as the soft materials can stretch and bend in too many different ways for sensors to detect all potential deformations.

However, the deformations that occur for a given application—like grasping and manipulation—are much more limited. In case of the RBO Hand 2 [2] the three main deformation modes of the actuators during manipulation are:

- **Flexional**: A displacement in the actuated direction.
- **Lateral**: The actuator bends to the side.
- **Twist**: A rotation about the longitudinal axis.

We developed a method that uses this task knowledge to find a sensor layout that captures the task-relevant deformations [1]. Using our method we identified a sensor layout consisting of only four liquid metal strain sensors [3] per actuator. By reducing the number of sensors to the minimum we keep the complexity low and reduce influence of additional sensors on the actuator’s compliance. The final sensor layout is shown in Figure 2.

The Sensorized RBO Hand 2 uses four such sensorized actuators as fingers. This way contact of the soft hand with objects and the environment can be detected, measured, and used to guide manipulation strategies.

II. DEMO DESCRIPTION

We demonstrate the Sensorized RBO Hand 2 during grasping and manipulation tasks (Fig. 1). The four sensorized fingers each are equipped with four liquid metal strain sensors. In combination with the pressure inside the actuator this allows us to predict the shape of each finger from the sensor data. When the fingers make contact during manipulation, the resulting deformations in flexional, lateral, and twist direction are measured.

During the demonstration attendees will be able to grasp objects with the Sensorized RBO Hand 2 and apply deformations to it. The live deformations will then be visualized on a virtual 3D model of the hand using the SOFA Framework. A screenshot of the visualization is shown in Figure 3.

This demonstration is based on work that was previously presented at the 2017 IEEE International Conference on Robotics and Automation [1]. All authors are with the Robotics and Biology Laboratory, Technische Universität Berlin, Germany.

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III. OUTLOOK

The strain sensors used for the sensorization add a sense of proprioception to the RBO Hand 2. This is similar to the Golgi tendon organ in the human [4]. The sensors measure differences in strain on different parts of the actuator, which allows to reason about the tension it experiences. Similar to the human, this information can potentially be used to create reflex-like reactions to unexpected events.

In the future this will enable the Sensorized RBO Hand 2 to not only tolerate contact with the environment, but actually use the sensor feedback caused by the contact to create reactive manipulation strategies and reason about grasped objects and environmental interactions.

REFERENCES