# Using Vision for Pre- and Post-Grasping Object Localization for Soft Hands[†]

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***Abstract*— In this poster, we present soft hands guided by an RGB-D object perception algorithm which is capable of localizing the pose of an object before and after grasping. The soft hands can perform manipulation operations such as grasping and connecting two parts. The flexible soft grippers grasp objects reliably under high uncertainty but the poses of the objects after grasping are subject to high uncertainty. Visual sensing ameliorates the increased uncertainty by means of in-hand object localization. The combination of soft hands and visual object perception enables our Baxter robot, augmented with soft hands, to perform object assembly tasks which require high precision. The effectiveness of our approach is validated by comparing it to the Baxter's original hard hands with and without the in-hand object localization.**

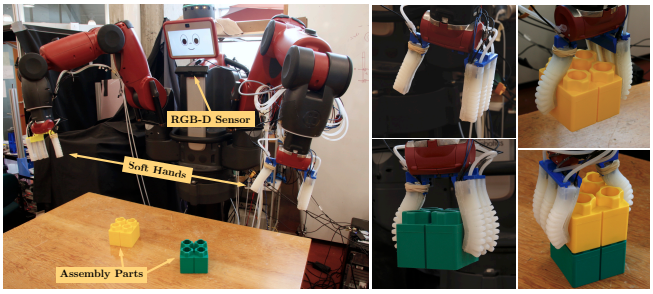
## I. Introduction

An important prerequisite for object manipulation is estimating the pose of an object and coping with the *uncertainty* of the pose estimates. Various sensing modalities, such as proprioception [1], [2], visual exteroception [3], and contact/force sensing [4] have been employed. Visual sensing allows passive perception as it does not require contact, and is thus useful in the *pre-grasping* phase. Tactile, contact, force, and proprioceptive sensing modalities are useful when robots interact with objects in the *post-grasping* phase. The pose of a grasped object can be quite uncertain as the act of grasping tends to move the object and increase the uncertainty. Many prior works have combined vision and contact to decrease uncertainty [5].

Soft grippers are more compliant and easier to control than their hard counterparts [6]. The flexible materials of soft hands enable compliance with discrepancy between their belief space and the real environment; this compliance allows soft hands to be more tolerant of errors in the pose estimates of objects. Softness, however, often reduces the confidence of the object state in the gripper since the pose of the object is more uncertain due to the flexibility of the soft fingers. In-hand object localization is thus needed for advanced object manipulations requiring accurate pose.

The goal of this work is to develop a reliable object manipulation system using soft hands and visual pose feedback and to evaluate its effectiveness. Fig. 1a illustrates our system setup in which the Baxter robot is augmented with two soft hands and an RGB-D sensor. We use vision for localizing objects presented to the robot on a tabletop and then determining the pose of a grasped object in the hand. Fig. 1b shows one of our soft hands, which is composed of four pneumatically actuated fingers [2]. An RGB-D sensor is employed to localize objects in the workspace of the robot in the pre-grasping phase and to detect soft fingers and a grasped object in the post-grasping phase. Our approach does not rely on proprioceptive force sensing, yet it is capable of assembly operations requiring precision. To the best of our knowledge, this is the first attempt to use a vision-based object localization for soft hands capable of assembly tasks.

The full poster will describe the details of our technical approach and present the experimental results.




(a) System setup (b) Soft hand

Fig. 1: **System overview.** Our system is composed of the Baxter robot augmented with two soft hands and an RGB-D sensor. Assembly parts are randomly placed on the table, so the positions and orientations of the parts are unknown. The RGB-D sensor localizes the parts on the table and inside the hand during the *pre-grasping* and *post-grasping* phases, respectively. The RGB channels are used for identification of the soft fingers, while the depth channel is employed for depth-based object localization.

## References

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