Toward Learning to Detect and Use Containers

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I. Introduction

Characterization of container affordances is a fundamental ability that infants learn through interaction and observation of objects in their environment [1]. Infants may learn about containers early because containers are fundamental to almost every facet of daily life. Knowledge about containers is generalizable to many applications including packaging, transportation, cooking, storage, protection, and organization.

One goal for the field of developmental robotics is to develop robots that perform useful work in unstructured settings. One of the grand challenges for robots proposed in [2] is the task of cleaning and organizing a house. Solving that task relies heavily on a robot's ability to understand the affordances of containers. Human environments offer multiple opportunities to learn about containers, with toy bins near to scattered toys, dishes near shelves, and clothes near laundry baskets. The field of robotics may be much closer to solving this grand challenge once robots are able to identify containers and learn how to use them.

The long term goal of this research is to program a robot with the ability to discover the potential for objects to conform to each other. Containers offer a generalizable paradigm and a good starting point down the path of achieving this goal. By giving robots the ability to understand and learn the properties of containers, robots may be employed to supplement humans in a range of laborious tasks.

II. Related Work

To the authors' knowledge, little previous work addresses the stated problem. Some research has focused on extracting 3D models of objects from the robot's sensory data, but these contributions focus on creating more accurate replicas instead of learning how to use the objects as containers. In contrast, Saxena *et al*, have shown that machine learning techniques may be used to classify object grasp locations without using 3D models [3]. Grasping points are frequently identified on the rim of containers. This learning scheme may be combined with other methods to solve the container classification problem as well as help with finding container openings. Further contributions in [3] employ the grasping locations to form grasping strategies, showing the robot's ability to unload dishes from a dishwasher. Loading dishes into a dishwasher could be achieved in a more generalizable way once the robot understands the properties of containers and how they can be used to achieve object conformity. However, the problem of giving the robot the ability to teach itself how objects conform to each other remains unsolved.

Infants' ability to learn and understand containment events is an essential topic in developmental psychology, which offers insights to roboticists. Baillargeon [1] shows that infants learn different container properties from the dynamics of a visual event (e.g., occlusion, containment, covering) at different stages of development. Analysis shows that infants create separate categories for each type of event, where factors known to affect one event are not always generalized to others [1]. These progressions provide further motivation for breaking down the object conformity problem into small event learning tasks.

III. Methodology

This research is currently emphasizing the ability to classify containers, learn the dynamics of containers, and learn to find objects that can fit into the containers. Image feature extraction coupled with object interactions by a 7-dof Berret WAM arm will be used to capture the essentials of a container for classification. The robot will start with a repertoire of exploratory behaviors (i.e., grab, lift, move, flip, drop). The robot will also have the ability to track objects in its field of view and extract their visual features (e.g., SIFT features). Using its behavioral and perceptual repertoire, the robot will interact with containers and other objects in order to learn their functional properties. Analyzing the sequence of interaction will show that opaque containers occlude objects put inside of the container, and objects put inside of the container move with the container. Containers also have the property that their contents come out when flipped over (i.e., the contents are no longer occluded). The robot will be evaluated on its ability to classify novel objects as containers as well as its ability to locate objects that may fit into the container.

References

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[3] A. Saxena, J. Driemeyer, and A. Ng, "Robotic grasping of novel objects using vision," *IJRR*, vol. 27, no. 2, pp. 157–173, 2008.