Duplo Bricks Sorting by PR2

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I. INTRODUCTION

This work is part of ongoing work on using manipulation by a humanoid or semi-humanoid robot as an aid to perceiving the environment better. This paper specifically demonstrates the ability of PR2 to sort a bunch of duplo bricks by length and color using data from a head-mounted Kinect.

II. RELATED WORK

Parts sorting is a very old field of research and very accurate vibration-based parts feeders have been designed in industries ([1], [3]). A parts feeder can not only sort but also position and orient bulk parts before they are fed to an assembly station and thus, help in micro-assembly. Work has also been done on sorting parts by shapes using Bayesian techniques and parallel-jaw grippers ([2], [4]). However, these methods assume availability of very specific equipment or require parts to be fed to the feeder one by one. Our goal is to use manipulation as a tool to aid perception in a household environment to understand it better. Sorting duplo bricks, a parts-sorting of a very specific kind, has been demonstrated as an example.

III. ALGORITHM

The complete sorting pipeline is depicted in Fig. 1. Details of the two main components - perception and manipulation - are given below.

A. Perception

The perception pipeline consists of the following steps:

1) A point cloud is received from the head-mounted Kinect camera.
2) The input point cloud is processed to obtain meaningful clusters corresponding to individual duplo bricks. To achieve this, several standard algorithms available in the Point Cloud Library (PCL) are used. The point cloud is first sent to a pass-through filter to retain data for just the table and the tabletop objects. Planar segmentation is then performed to extract out the table and leave the objects point cloud behind.
   The Euclidean clustering algorithm is modified slightly to take into account the color of the clusters as well. Since every duplo brick is a single-color object, we look for neighboring points of the same color and if such a set of points satisfies the criteria of the minimum and the maximum number of points in a cluster, we obtain a cluster possibly corresponding to a single duplo brick. Euclidean color-based clustering allows two bricks of different colors to be distinguished from each other even if they are in contact and their point clouds overlap.
3) First such cluster obtained is sent to the grasping pipeline for manipulation.

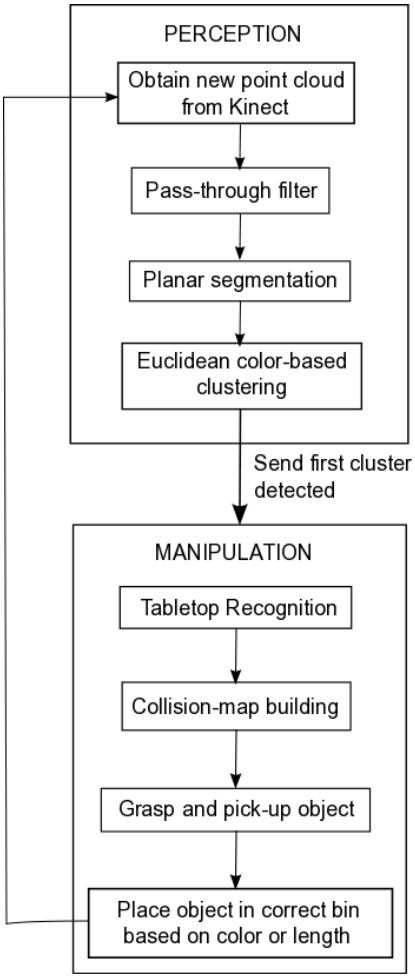

Fig. 1: The complete duplo sorting pipeline combing perception and manipulation

Fig. 2 shows the steps in the perception pipeline. We see that though Euclidean color-based clustering gives reasonable results, some clusters are incorrectly identified while others are not identified at all.

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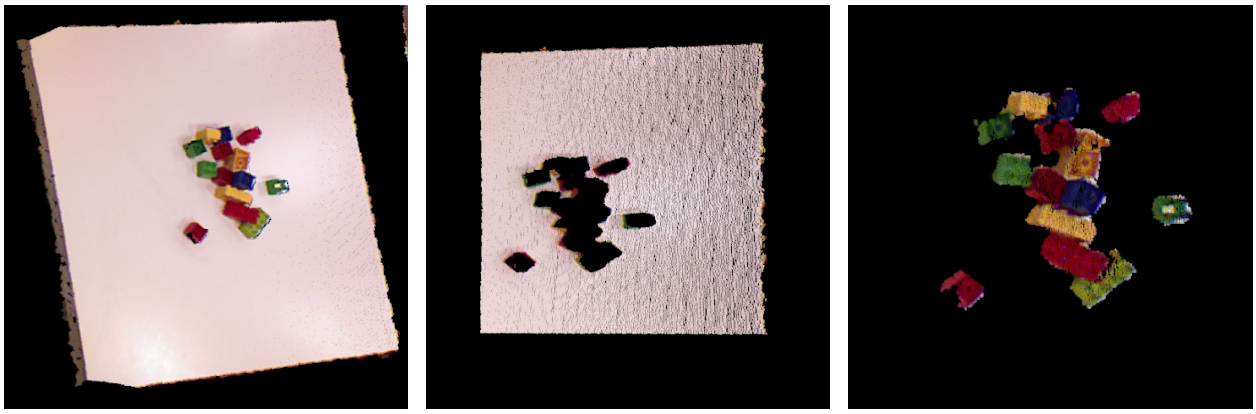

(a) Filtered point cloud (b) Extracted table (c) Object point cloud

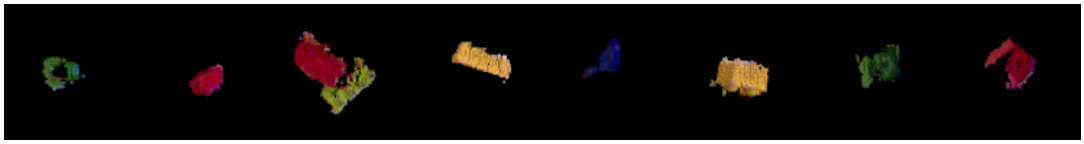

Fig. 2: Clusters obtained from Euclidean color-based clustering

B. Manipulation

1) The PR2 tabletop manipulation pipeline is largely used here. However, collisions with other duplo bricks and the table while grasping a duplo are now acceptable and, thus, allowed. The cluster received from the perception pipeline is set to be the graspable object and once it is picked up, the arm moves to a pre-defined bin position based on the color or length of the brick and drops it in the bin.
2) Since the pickup action may disturb other bricks, the complete perception pipeline is repeatedly called for each brick until the table is cleared. This also makes the algorithm adaptive to any disturbances in the scene (like bricks being added or removed) while the pipeline is running.

IV. EXPERIMENTS & RESULTS

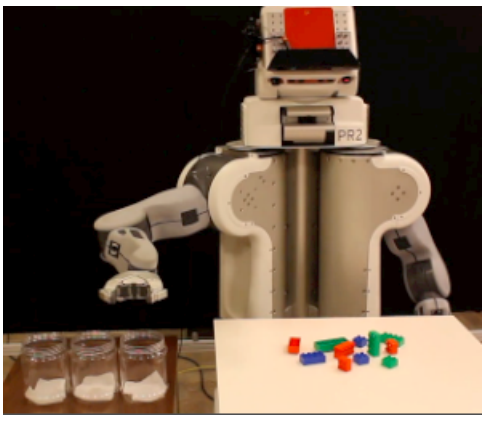

Fig. 3: Experimental setup

Duplo bricks were scattered on a table placed in front of the PR2. It was ensured that the bricks did not pile on top of each other for these experiments. Fig. 3 shows our experimental setup and Fig. 4 shows the results of sorting the bricks by color and length respectively. We also obtained

(a) Sorted by color (b) Sorted by length

Fig. 4: Sorting results

accurate results for more cluttered scenes when the bricks were in contact with each other even though it took longer for the sorting to finish.

V. CONCLUSION

We have demonstrated a simple pipeline combining perception and manipulation on the PR2 that sorts duplos by length or color accurately. Ongoing work involves accomplishing this task in more cluttered scenes as well. We hope to show that intelligent manipulation of an environment by a robot can significantly improve its perception and, thus, its understanding of the world.

REFERENCES

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