Multi-Object Grasping – Stochastic Grasping from a Pile

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***Abstract*—Grasping multiple objects at once from a pile is common for humans. It makes us efficient in pick and transfer tasks. It is essential for a robot to gain multi-object grasping capability (MOG). This paper defines the multi-object grasping problem and introduces several novel multi-object grasping techniques. These techniques include probability-based pre-grasp potential calculation, a stochastic flexing/extending routine, obtaining end-grasp types, and estimating the number of objects in a grasp. It also proposes a new stochastic grasping strategy for grasping a desired number of objects.**

***Keywords*—Grasping; Dexterous Manipulation; In-Hand Manipulation**

I. Introduction

Picking up one item at a time has been standard practice in robotic bin-picking and pick-and-place applications. However, this approach is inefficient compared to humans who are capable of picking multiple objects at once. It is essential for a robot to gain multi-object grasping capability (MOG). There are some work related to MOG before [1]–[9]. However, none of these works consider how to grasp multiple objects from a bin. In our previous work we have conducted a series of research related to MOG. In [10], we have analyzed how to estimate the number of objects in a robot grasp while the hand is still buried in the pile of objects. In [11], we have developed a Markov Decision Process based transferring algorithm for robotic batch picking, showing efficiency of grasp-and-transfer considering MOG. In [12], we have collected MOG data of human wearing a 5DT data glove and robotic grasping utilizing a Barrett hand robotic system, then proposed 12 MOG grasping types summarized from the data we have collected.In this work, we are focusing on developing a MOG grasping algorithm for picking up a desired number of objects at once from a pile.

II. proposed Approach

A. Stochastic MOG Synergy

In our initial exploration, we have found that certain pre-grasp poses and end-grasp poses are related to grasping and picking up a particular number of objects from a pile. We have summarized the end-grasp poses in 12 different grasp types in [12]. Therefore, we have developed an approach to identify the best pre-grasp poses and a stochastic flexing/extending routine to find the best end-grasp poses for MOG. Once we have obtains the best pre-pose and the end grasp pose, we use their difference to calculate the flexing pace - MOG synergy.

B. Grasping with MOG Synergy

When grasping a desired number of objects, the fingers keep flexing based on the obtained MOG synergy until the lower bound of the stop criteria has been met. Then the deep neural network object number estimator will run to check if this grasp has the desired number of the object or not. If the classifier predicts the grasp has the desired number of objects, then the hand will lift. Otherwise, the hand will go back to the pre-grasp and try it again.

C. Data collection and experiment setup

We perform data collection to find the best pre-grasps and MOG synergy for 40mm sphere, 45mm sphere, medium cylinder and tall cylinder in simulation, as well as for ping-pong ball with 40mm as diameter in real system. The setup of both the simulation and real system are shown in Figure 1. We are trying to precisely grasp the target number of objects from the bin using the Barrett hand attached to UR5e robot arm.

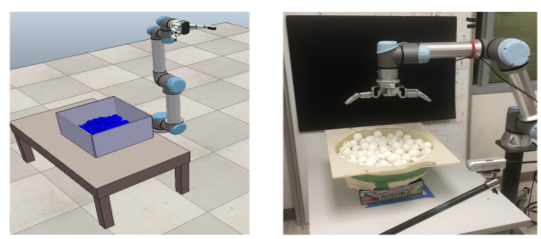

Fig. 1. Set up of our system in CoppeliaSim (left) and real system (right)

III. Results

To evaluate the stochastic grasping strategy, we implemented the strategy for grasping 2 and 3 objects. We ran the strategy 50 times and computed the RMSE. The results are shown in Table I.

TABLE I
Result of Grasping algorithm

Target number	Stochastic F/E (before PPG)	Stochastic F/E (after PPG)	Stochastic grasping strategy	Averaged re-grasps	Averaged objects per grasp
2 40mm sphere	0.436	0.387	0.346	2.3	1.5
3 40mm sphere	0.742	0.686	0.557	0.7	2.0
2 50mm sphere	0.4	0.346	0.2	3.9	1.6
3 50mm sphere	0.592	0.624	0.52	4	1.0
2 mixed sphere	0.374	0.53	0.316	1.4	1.1
3 mixed sphere	0.624	0.5	0.5	0.5	1.9
2 medium cylinder	1.306	1.201	1.02	0.26	1.36
3 medium cylinder	1.513	1.467	1.42	0.06	2.02
2 tall cylinder	1.482	1.223	1.15	0.34	1.36
3 tall cylinder	1.602	1.514	1.47	0.38	1.98
2 real ping-pong ball	0.332	0.283	0.265	0.2	1.68
3 real ping-pong ball	0.608	0.5	0.4	0.3	2.46

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