I. Dexterous Manipulation Graph Results

A. Overview

In this section, we show example evaluations for tasks that involve both desired hand pose and desired contact points with the object. We use the Dexterous Manipulation Graph method (DMG) [1], which is a planner for in-hand manipulation that is based on a graph representation of the object's surface, obtained through the object's discretization into small areas. Since the execution is treated separately (e.g. it can be push against the environment, bi-manual push, ...), we focus only on evaluating the planned solution.

B. Setup Details

The DMG planner is used to find an in-hand manipulation solution for an ABB Yumi smart gripper. We select some of the contact region tasks that was defined in the benchmarking protocol, and defined H_i and H_d accordingly. Since the DMG defined in [1] is designed for parallel grippers, two contact points per hand are defined. We also define initial and desired poses P_i, P_d. Due to the gripper's structure, its position can be derived using a translation from the middle point between the two fingertips. All the executed tasks are available in our website.

C. Results

Table I shows the results for planning in-hand manipulation paths. Each column corresponds to a different task with a different object. Each row shows the metrics proposed in the in-hand manipulation benchmark, and the planning time. The planning times are referred to computations on an Intel Core i7-6700 3.40 GHz×8 with 16 GB RAM running Ubuntu 16.04. The evaluated method requires offline computation of the Dexterous Manipulation Graph structure, which is then reused for any in-hand manipulation task on the same object.

References

[1] S. Cruciani, C. Smith, D. Kragic, and K. Hang, "Dexterous manipulation graphs," in *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Oct 2018, pp. 2040–2047.

TABLE I: Metrics for the DMG method.

Object	gelatin box	cracker box	spatula	potted meat can
err_{pos} (cm)	0.505	0.267	0.513	0.610
$err_{pos}\%$	9.9	2.7	8.8	11.0
$err_{or}\%$	0.016	0.044	0.023	0.049
G_{euc} (cm)	1.125	0.862	0.746	0.663
G_{geo} (cm)	1.127	0.862	1.505	0.663
G_{min} (cm)	0.013	0.057	0.034	0.004
DMG time (s)	10.312	15.467	13.406	18.295
Plan time (s)	0.023	0.004	6.7e-05	0.002