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Team D - HARP

Teammates – Alex Brinkman, Rick Shanor, Abhishek Bhatia, Lekha Mohan

ILR07

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Individual Progress

Our team's main priority this week was submitting the application and demo video for Amazon Picking Challenge 2016. I recorded the video to demonstrate that shelf localization was robust – tracking was maintained even with sudden shelf and Kinect movements.

A major issue we faced was that the default UR5 path planner was generating complex trajectories with wrist rotation even when a much simpler path existed. This kind of motion would exert large torque on the suction tube and damage it. I worked with Alex to solve this. We had to manually restrict the joint angle limits of the robot so that all the shelves could be accessed while minimizing wrist rotation. The URDF was modified and the joint angles were visualized using the MoveIt setup assistant.

I also found that the collision mesh object for the UR5 Kinect mount was incorrectly configured. As a result, collision checking was not being performed for that mesh. I resolved this issue using Blender.

Later, we realized that the incorrect trajectory generation was caused by the reduction in workspace of the UR5 due to the geometry of the end effector. The Kinect was mounted such that it collided into the joint of the UR5 arm when rotated, greatly restricting the movement of the robot arm. Alex and Rick fixed this by designing a new end-effector with the Kinect mounted below the axis of the arm.

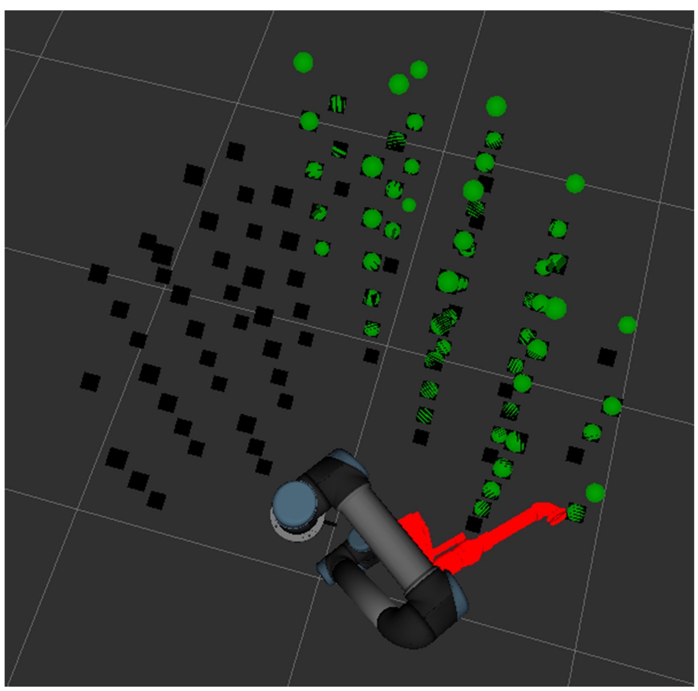

Fig 1: UR5 workspace with end-effector

The above figure shows the workspace visualized by Alex. The green spheres show the initial restricted workspace. The black cubes show the final expanded workspace.

I have been studying grasp planning and understanding how grasping surface for suction differs from manipulator grasping. I am also learning Point Cloud Library for performing patch smoothening, clustering and grasp surface estimation of the ground truth models.

Another major design decision was to split various features into git branches. It was becoming very hard to keep all the features running in one branch. So we refactored our code into separate git branches for grasping, interactive markers and perception. I also added the mounting frame of the UR5 base as a collision object.

Challenges

For progress review #8, we had initially promised on setting up the UR5 robot platform and demonstrating that we could access all the shelf bins using tele-operation. However, we could not meet it as the vendor required a payment order which had to be processed through University Contracts. As a result, we had to modify our goals. This had also prevented us from demonstrating the UR5 for our APC video submission.

My main challenge was working with PCL to understand the metrics for determining the optimal grasp surface for all the test items.

Team Work

Lekha worked on offline grasp planning. She used saved pointclouds to study and determine the best grasp surfaces using normal estimation, cylinder segmentation, smoothening and clustering. She is also developing a GUI to manually remove stray normals. Alex used a version of this normal estimation to demonstrate grasp planning using MoveIt!. The figure below shows the normals for the Cheez-it box which was obtained using smoothening and clustering.

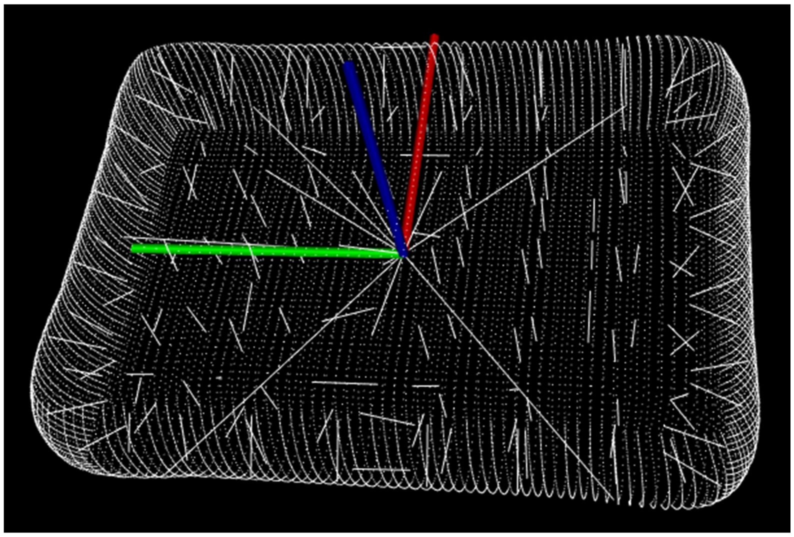

Fig 2: Estimated normals of smoothened Cheez-it box

Alex and Rick redesigned the end-effector to position the Kinect below the arm axis and modified the URDF configuration files. Alex then computed the configuration space of the UR5 and visualized it in RViz using markers. Alex also helped me with refactoring the git branches.

Rick worked on creating the video demo and voice-over for the APC submission. He has also been working with Venkat from Search Based Planning Lab to test their PERCH perception algorithm for our use-case. The PERCH system uses graph-search algorithms for pointcloud segmentation and has been found to be particularly effective for cluttered spaces with occluded items. Rick plans to benchmark PERCH against our current item identification system.

Rick also created a GUI program for annotating pointcloud scenes for testing the perception pipeline. This program allows the operator to manually align the ground truth model with the pointcloud scene from Kinect and save the pose. Eventually, we plan to have a dataset of 100+ scenes. This will then be used to evaluate the performance of PERCH and our ICP algorithm for item recognition.

Abhishek worked on the test plan and created the video for grasping subsystem. He assisted Rick with setting up PERCH. He is also testing the Object Recognition Kitchen ROS package to see if it can be modified to suit our application.

<u>Plans</u>

Our goals for the next progress review are to demonstrate UR5 accessing the APC configuration space autonomously and evaluate the deviation in localization with the integrated system - Kinect, UR5 and shelf.

I will be working on quantifying and developing grasping models and benchmarking different approaches. I will also be testing SimTrack which is a ROS package for detecting poses of multiple rigid objects.

I will also be helping Abhishek and Alex to setup Kinect kinematic calibration.