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**Team D - HARP**
**Teammates – Alex Brinkman, Rick Shanor, Abhishek Bhatia, Lekha Mohan**
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**Individual Progress**

Since the last review, I have been working on developing and improving grasping techniques for the new shelf and adapting it for the official APC 2016 items.

Shifting to the new shelf created many issues. The aluminum shelf surface was reflective and caused artifacts in the Kinect point clouds. The shelf bins are also slightly tilted down and have a lip/protrusion near the edge of a bin to prevent items from falling down. This caused the items to collide while being withdrawn with the UR5 arm. There was also lesser shelf clearance requiring us to redesign the end-effector. The new end effector was flatter and the suction cup was smaller – requiring us to accurately contact the grasp points. Previously, if the end effector was near the item, the suction cup would wrap around the object and successfully grasp it. I had to rewrite the grasp planner and tune offsets for the arm dynamics and vision pipeline.

The new shelf was also deeper than expected – our existing end-effector could not reach items kept at the furthest end of the shelf. To remedy this, Alex extended the end-effector tube and we updated the URDF model. Extending the arm increased workspace constraints – planning time increased and undesirable paths were generated.

I worked with Alex to develop multiple techniques to improve planning for the grasp points. It was hard to reach items at the end of the shelf if we approach it straight. Instead, we generated 3 grasp orientations for every item with a 10 degree difference. This way, we could reach items at the shelf corners easily. Figure 1 below depicts these orientations.

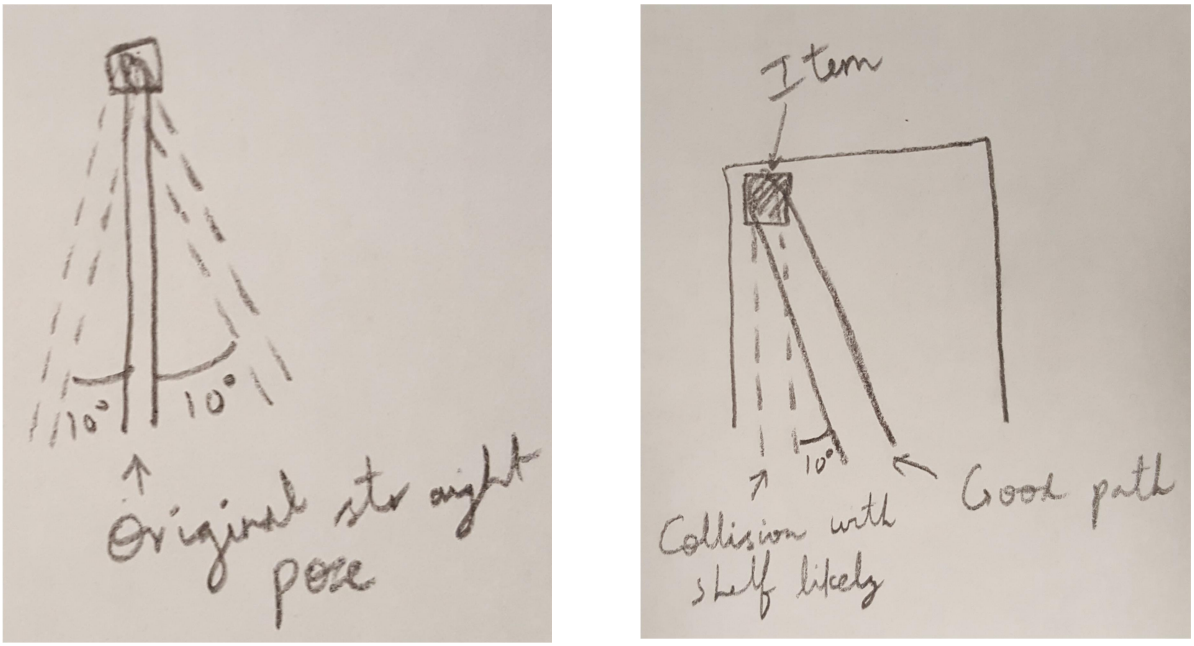


Figure 1: Generating bent grasp orientations for reaching shelf edges

I worked on benchmarking and tuning the grasping system to accurately reach grasp points. For testing, I used a cylindrical plastic bottle of glucose tablet whose diameter was slightly more than the suction end-effector. This allowed me to fix offset errors in the kinematics of the system.

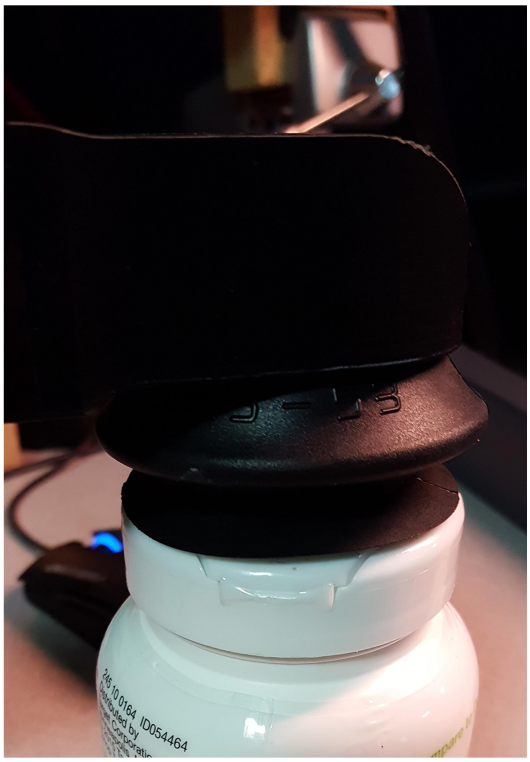

Figure 2: Benchmarking grasping with glucose bottle

I added the order bin as a collision object for the planner. I also fixed a bug which caused the online grasp planner to crash or generate incorrect grasp points if the shelf was empty or if pointcloud quality was low.

## Challenges

We noticed that while creating trajectories from one bin to another, the MoveIt planner kept generating paths which collided against the shelf wall. This happened repeatedly and was probably caused due to sparse walls in the STL collision model file.

Since the new shelf bins are smaller, it is hard to get dense point clouds from the Kinect with the severely limited viewing angle. As a result, the grasp points were generated with incorrect

positions and orientations. We tried to force all grasp points to have an orientation along the vertical Z axis.

**Teamwork**

Rick and Bhatia integrated the new CNN perception system which could identify multiple items in a shelf bin. Rick created an 80/20 aluminum mount for the new order bin. He also created an STL model of the order bin.

Alex worked on refactoring the move_arm_server node and added features allowing us to specify Cartesian or single query paths and to break movements into multiple parts. We worked together to test and integrate the system.

Lekha worked on generating models of the new items using Autodesk 123D Catch. This will be used for testing Perch – search based pose detection algorithm from SBPL.

**Plans**

We are ironing out a few bugs and preparing for the Spring Validation Experiment. Our primary focus is to improve system performance for the Amazon Picking Challenge.

Our current approach of top-down grasping would not work for many orientations of certain flat/thin objects. Also, for cylindrical items such as the glucose bottle, grasping from the side would be easier than grasping from the top. I am working on a pipeline to decide between sideways and top-down grasping for a given item and pointcloud. I will also be generating trajectory plans for these sideways grasping surfaces.

We are currently using an STL mesh of the Kiva shelf which is non-convex and increases planning time. To speed up planning, I will be switching to convex collision objects by replacing the entire Kiva shelf with a cuboid of similar dimensions.

Lekha and Alex are working on fixing sparse point clouds generated by items that are specular or reflective. Bhatia is working on improving task planning strategies.