Progress Review 7

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Team D: Human Assistive Robotic Picker

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ILR06

January 28, 2016

Individual Progress

Since last progress review, the team's direction has shifted. Specifically, we are in the process of borrowing a UR5 from Universal Robotics for the semester. I have been working on several aspects of our pick and place robotic system in preparation of receiving this hardware. First, I designed a base for the UR5. Second, I designed and manufactured a mount for the Kinect, which will attach to the end to the end effector mounting holes on the UR5. Third, I wrote a localization algorithm to identify the location of the shelf with respect to the robot. Finally, I packaged both the vision pipeline code and the localization code into ROS.

The UR5 does not ship with a base attached to it. The base is designed to hold the robot at the appropriate height such that all bins can be reached. The base is designed using 80-20 to simplify fabrication. In addition, 80-20 is highly modular if any changes are ever necessary. Figure 1, below, shows the UR5 arm CAD reaching into the shelf, sitting on this base. Fabrication of the base has begun and will be finished early next week.

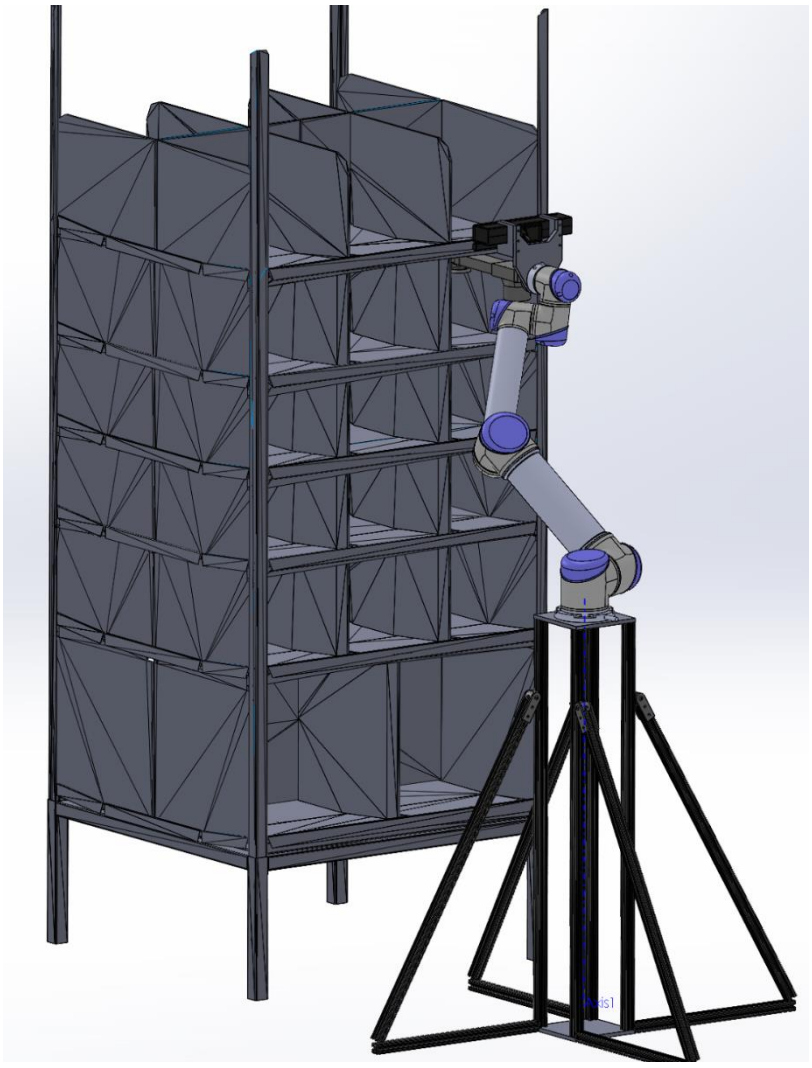

Figure 1: UR5 Arm Reaching into the Shelf

Second, I designed a mount for the Kinect, to connect the sensor to the arm. The CAD of the mount can be seen attached to the top of the arm in figure 1. The fabricated mount is shown in figure 2 below. The sensor sits above the end effector and looks down into the shelf. The mount was laser cut from acrylic to speed up the fabrication process and prepare for the delivery of the arm next week.

Figure 2: Kinect UR5 Mount

Next, I wrote localization algorithms to identify the location of the shelf. The algorithm matches the ground truth CAD model of the shelf to a depth map captured by the Kinect. An iterative closest point algorithm is used to minimize the distance between points in the scene and the shelf model. A first iteration of this algorithm ran non-stop, constantly updating a prediction of the shelf location. However, since the UR5 is a stationary manipulator, this algorithm only has to run once. I wrote a ROS server that captures images from several locations and locates the shelf only once. The algorithm is able to identify the location of the shelf to within millimeters.

Finally, I packaged the perception pipeline into a ROS server as well. The main state controller passes this server the bin information. The server then captures an image, loads the ground truth models, clusters the scene, and runs the vision algorithms. The vision algorithm returns a grasping location, which for now is just above the centroid of the object. The code was written such that more advanced grasping strategies can be implemented down the line. With this vision pipeline packaged into ROS, we were able to implement a hardware in the loop simulation which uses real Kinect data to localize the shelf and to identify items. The robot, in simulation, grabs these items off the shelf and places them into the bin. Figure 3 shows the robot grabbing the Oreos off the shelf.

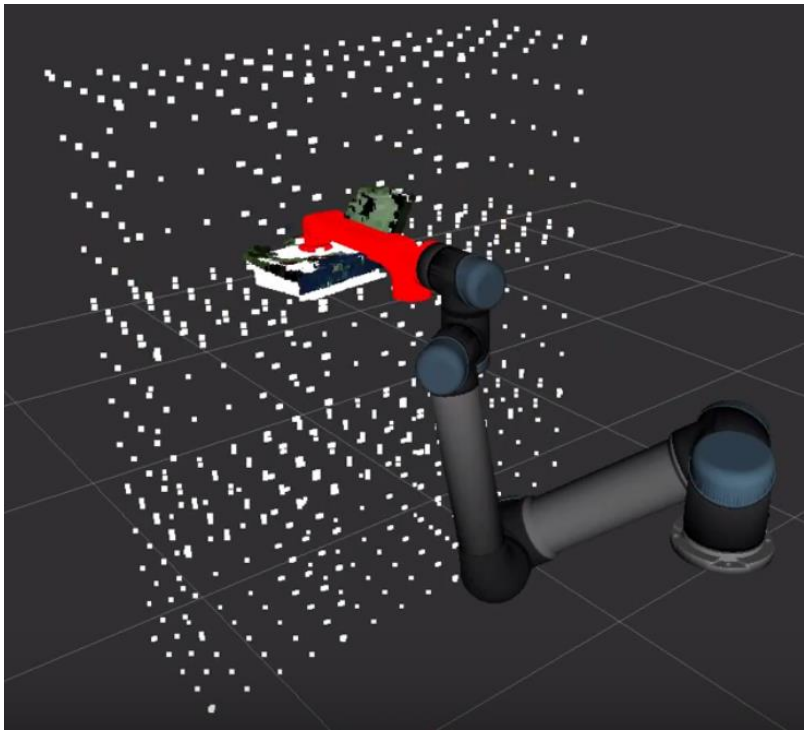

Figure 3: UR5 System Simulation Test

Challenges

There were some challenges coordinating our efforts over the break, and as a team we did not accomplish as much as we would have liked. In addition, we are pushing to get the UR5 as soon as possible. However, the deadline for the Amazon Picking Challenge submissions is February 5th. Thus, it is unlikely we will be able to submit a hardware video by that time. Finally, I am working to improve and adapt perception algorithms for more cluttered shelves.

Teamwork

Alex did a lot of work to make a new gripper that is lower profile and also rotates to decrease the moment of the vacuum hose. In addition, he led the effort to pull in the UR5 into our SMACH framework. Finally, he has been working with SBPL to improve arm planning. Feroze has been working on generating a collision model and integrating collision planning into MoveIt. Abhishek and Feroze began planning strategy for the stowage task. In addition, Abhishek has been starting to integrate algorithms from Object Recognition Kitchen so that we can baseline this tool against our perception algorithms. Finally, Lekha integrated input handling into the SMACH controller. She has also been developing a grasping algorithms based on surface normals.

Plans

Before next progress review, I need to build the base for the UR5. Assuming the UR5 arrives next week, a lot of my time will go into getting that up and running. In addition, I want to investigate the SimTrack object recognition pipeline. Finally, I am going to make localization more robust and fine tune the localization pipeline to work with the arm. If necessary, I am going to research ways to calibrate the arm to Kinect transform accurately.