ILR #11
Amazon Picking Challenge

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Team E
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Individual Progress

My duties for the last two weeks involved spec'ing and procuring hardware for our shelving system, debugging our electronics and controls for our slider and 1-DOF, and fixing the issue we have been having with the quaternion orientations of our generated grasp poses. In addition I spent a large amount of time with the team working on integrating our system for PR demo, in order to incorporate new system features.

Project Management

I am doing my best to keep everyone on task in these last few weeks, but it is becoming more of a challenge with my own tasks building up and with exhaustion and other course projects becoming a larger factor for everyone. I am trying to encourage the team to take more ownership for their own tasks and the project as a whole to try and bridge the gap I am leaving currently. Current management on my part is mostly consisting of semi-daily check-ins with my teammates about their tasks and reminders about the time critical nature of the next couple weeks.

Shelf Hardware

I managed to procure the sheet aluminum for our new shelf drawers and have them waterjet at NREC. My first priority after receiving the material was validating that I was still capable of welding sheet aluminum in a robust enough manner for our project (I took classes on it years ago but have not touched a welder since then). Thankfully I was able to reliably weld together the sheet material into a workable drawer for our purposes, as seen in Figure 1. This means I can weld the rest of the material as needed without looking to outside fabricators, as originally planned in our project outline. Welding the drawer required procuring the appropriate clamps and materials (such as weld rod, brushes, etc.), and becoming familiar with the TIG welder and workspace inside of Chuck's shop.

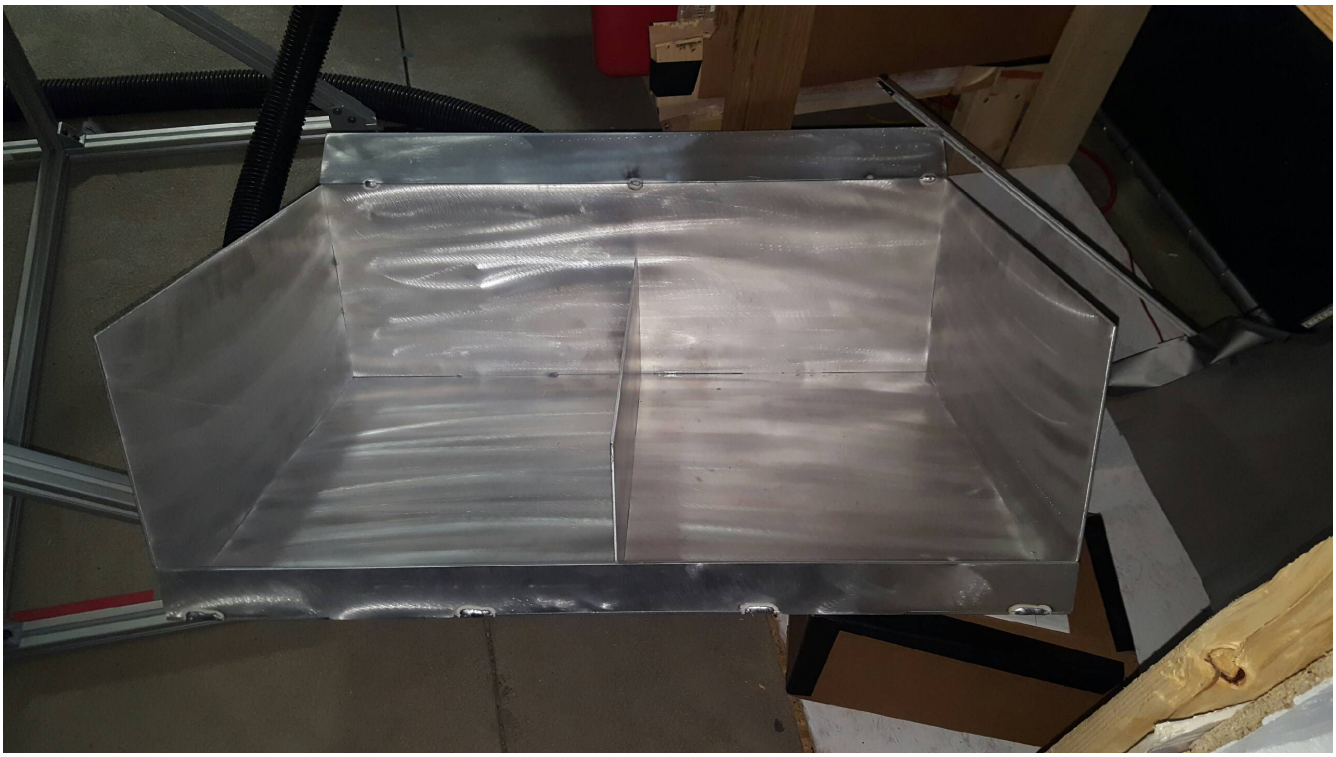

Figure 1: One of four final drawers for our shelf system.

There has also been a remaining issue with the shelf design regarding tolerances of rail pieces and fasteners, which has been resolved (within a satisfactory assembly precision of .01mm). I met with Joe from Intek and that meeting plus extensive research and model fitting with 80/20 materials solved this issue, and I should be drafting a full CAD model in the next couple days for the order.

Slider and 1-DOF

Having our first motor controller die severely set us back on our goals. Accordingly I made sure we took every precaution with the new installation, including heavy duty voltage regulators and an on/off switch across the cap bank of the 24V power supply as recommended by RAF Automation. After reassembling I wrote Arduino code for both the slider controller and our 1-DOF suction head that was more convenient for troubleshooting outside of the ROS environment. After verifying the functionality the integration into ROS went much more smoothly for both components, and we have had no issues to report so far. The 1-DOF now has it's own dedicated power supply and ports for cleaner wiring as well.

Grasp Pose Quaternions

Our past two demonstrations have featured grasp poses with hard-coded orientations in the vertical direction, which is not sustainable due to the need to have

pivoted picks in cluttered environments. Our grasp planners orientation generation has been wrong, and Akshay was unable to find the cause after working with it for some time, so I stepped in. I narrowed it down to a python function which uses two vectors to generate a quaternion. The math for this function has more than one solution, and the function always defaults to one solution, making it unuseable for consistent final pose generation. Because the solution is consistent however, I was able to create modification functions for post-processing, which rotate the output orientation to a desired pose based off of their location in relation to our system's world frame (The pose must twist accordingly with it's relative position to the arm, whether that be behind, in front, to the side, etc. Figure 2 shows the debugging tool that Akshay developed which I used to troubleshoot the problem, and Figure 3 shows my base logic I used to resolve this issue, which involved moving from quaterion orientations to Euler, and then back to quaternions, while accounting for our system's ZYX orientation (in comparison to XYZ).

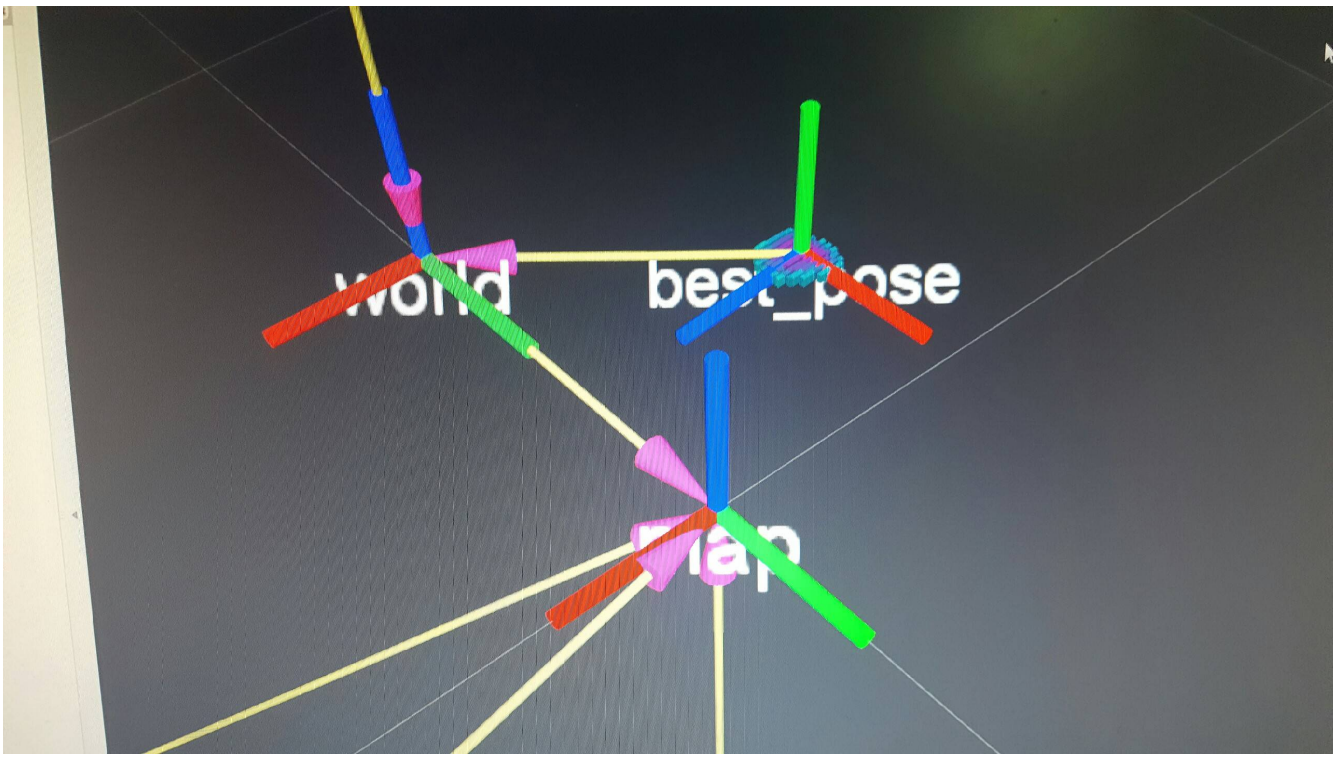

Figure 2: Grasp pose debugger. Shows transform orientation and best/worse normals generation in relation to the system world frame.

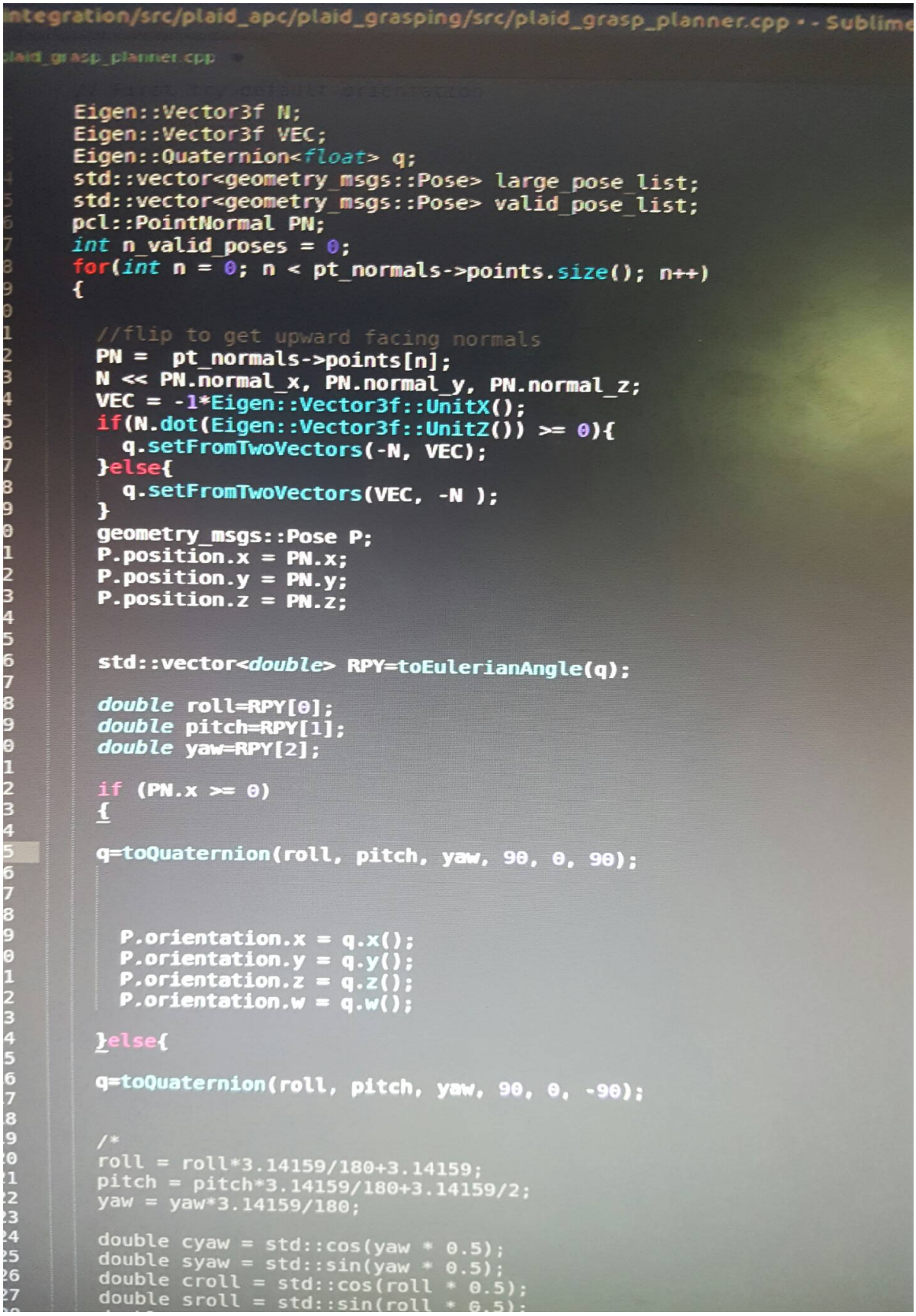

Figure 1: Primary logic for quaternion fix/resolution. The logic adds to the setFromTwoVectors() function in order to create a reliable and discernible pose.

Challenges

Tensions Between Team Members

As we are nearing the end of the semester exhaustion and tensions are running high among team members. We are occasionally having arguments or other unproductive disagreements in relation to task assignment and group work. I am doing my best to try and mitigate these issues as they occur, but have also found myself having this behavior occasionally in times of high stress (as many of our post 3am work sessions have been).

SBPL Library Debugging

The SBPL planning library has been a great resource for our project, but for this demonstration we hit a wall where a function inside the library conflicted with our 7-DOF functionality, and because of our inability to access and modify the core code we were unable to solve the conflict. Moving forward we are communicating with SBPL about how to solve the issue and potentially having the planner code modifiable within our system in order to avoid this issue in the future.

SBPL Lab Priorities vs. MRSD Course Requirements

System integration showed our item classifier to be the weakest aspect of our system by far currently. I had some inclination that our classifier wasn't where we needed it to be, but I hadn't realized just how bad it was until this past weekend. There have been conflicts with task delegation when negotiating with SBPL about retraining our classifier on the current shelf system, which were dismissed by the lab as a waste of time when compared to training for the unknowns at the competition or other goals. I tried to emphasize during these meetings that this training was important for our course requirements outside of the competition priorities, but these concerns have mostly been ignored. I wish I had made this more of a critical point during meetings, I think I could have done better to test our classifier to understand just how poor it is currently performing before now.

Teamwork

System Integration

The whole team worked roughly 40 hours this weekend to integrate our new state machine, slider mechanism, grasp poses, lighting, and (attempted) 7-DOF functionality, with Leo, Matt, and myself putting in between 12-15 hours each day since Thursday. We learned a lot about the robustness of our system and lower level components of ROS

interfaces from this integration, and all of us felt that we have a more fundamental understanding of our system in a significant way than we have during previous PR preparations.

State Machine Updates and Calibration

Leo worked heavily to update our state machine to handle bin to bin processing, including point cloud segmentation, and JSON handling. He also spent time to develop ICP for better bin localization, which was critical to our accurate grasping during the PR

System Lighting

Jin tested several different LED strips and diffusion materials on our system to try and produce the maximum brightness possible while reducing glare on spectral items. She also worked to try and "push out" ambient lighting as much as possible.

Grasping Primitives and Debugger

Akshay created a grasping debugger which I used to fix our grasp pose issue, and has been working on trying to create normals cluster primitives for our grasp planner, which will give us more robust grasps on tilted or misshapen objects.

Future Plans

My personal goals for the next 2 weeks involve helping my teammates to integrate and improve all of our final system components, and to try and have our core shelf installed and operational by SVE Encore. All of us our taking tasks as necessary at this point, but Matt is giving particular attention to 7-DOF capabilities and planning efficiency, Akshay to our classifier and data collection, Jin to our unknown item strategies for the competition, and Leo to point cloud segmentation for our new classifier and potential automated or outsourced labeling methods.