Alex Brinkman

Team D: Project HARP (Human Assistive Robotic Picker)

Teammates: Abhishek Bhatia, Lekha Mohan, Feroze Naina, Abhishek Bhatia

ILR #3: Progress Report

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1. Individual progress

Last week, I contributed to getting the Kinect2 integrated in ROS, added functionality to the SMACH state controller, designed and fabricated parts for the suction system, and helped create the PR2 teleoperation demonstration.

After learning the PR2 operates on Ubuntu 12.04 and ROS version Groovy, we decided to change our workstation computer to match to reduce incompatibilities. We first got the original Kinect to work in ROS Groovy before attempting to get the Kinect2 working. Abhishek and I worked on getting the Kinect2 integrated and eventually succeeded with a networked solution since the new Kinect2 relies on USB 3.0 which will not be available on the PR2 platform.

I created an initial rough version of the SMACH state controller to demonstrate how it will control our autonomous functions and handle user data returned by the service, actions, and custom function calls. Figure 1 shows the state machine viewer of this simple outline, each node is shown in an oval and represents a distinct service, action, or custom function call defined in the software specification.

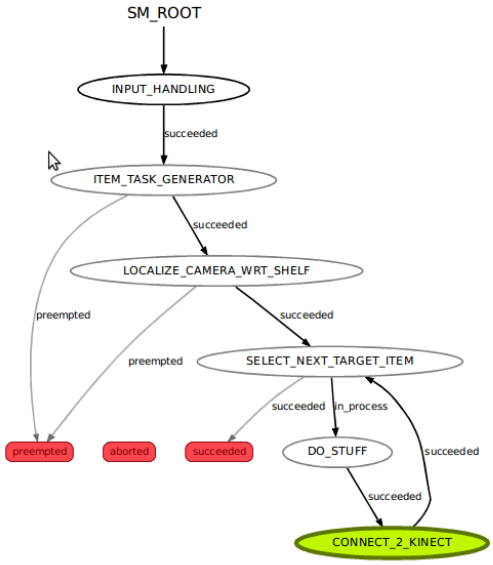

Figure 1: Rough draft of state Controller

Feroze and I were able to first establish how the Kinect data would be accessed by the state controller and demonstrated correct function. Later, Abhishek and I integrated the Kinect2 and demonstrated the same functionality operating over a networked configuration, similar to the project class ROS assignment.

Using the skills developed in the machine shop class, I was able to fabricate 2 mounting blocks designed to fit into the gripper of the PR2. This enabled us to quickly prototype a hand hold for the PR2 to use in the teleoperation demonstration.

Additionally, Rick and I worked on improving the suction system using the MRSD lab ShopVac The high-flow vacuum worked the best of all the options we tried. We decided we would try to modify the suction cups themselves to prevent the restriction in airflow the metallic fittings would present to the high-flow system, this initial idea is shown in Figure 2. We were able to create a prototype that proved it could work on even the most difficult items in the 2015 item dictionary. The resulting prototype can be seen in Figure 3 and a video of the demonstration can be found on our team website.

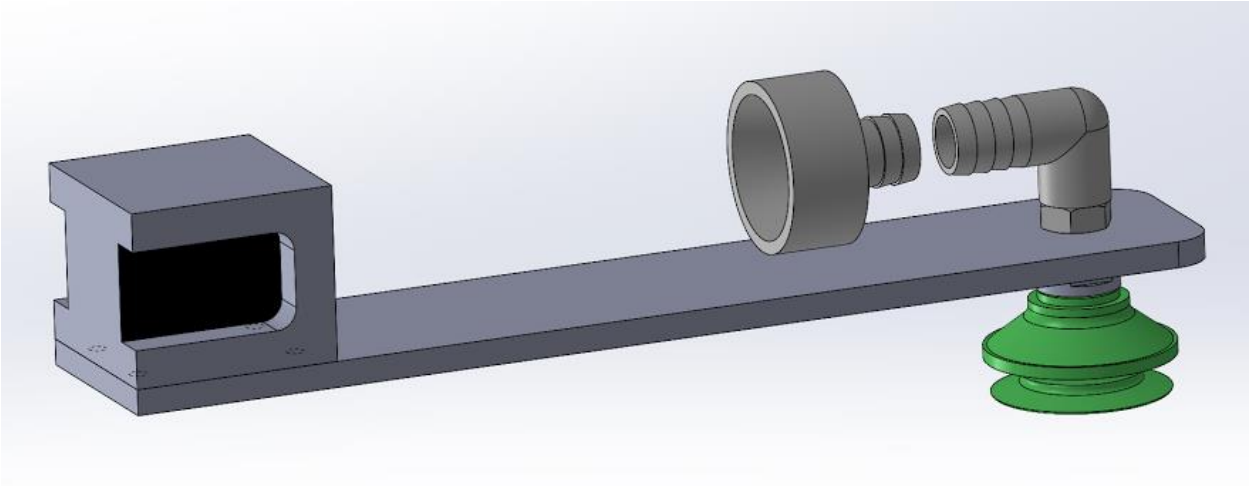

Figure 2: Restrictive Prototype

Figure 3: Actual Prototype

This week was also the first time we were able to log in to the PR2 and tele-operate the system. We took this opportunity to log the ROS topics and services used during teleoperation to better understand the PR2 system. The teleoperation of

the base was intuitive using a PS3 controller however the teleoperation of the arms was not as easy. In the end, we were able to create a successful teleoperation demo and show the PR2 and our suction system can effectively be used for the Amazon Picking Competition.

2. Challenges

The major challenges I faced this week were the Kinect2 integration and the suction system prototype. The Kinect2 requires USB 3.0 support which makes things harder to integrate on the PR2. We decided the improved resolution of this sensor is worth the added difficulty of a distributed computer system. We were able to eventually get the kinect2 working on a Lenovo Thinkpad and set up the network parameters to send data to our workstation over the ROS assignment router. On the PR2, we will be connecting with a laptop either purchased with our MRSD funds or provided by the SBPL for this purpose.

When we were designing the suction prototype, we began by sizing pipe and fittings based on the suction cups we have in our possession. Using the pressure sensor we acquired 2 weeks ago, we estimated the pressure drop at full restriction of the ShopVac to be around 10 Kpa which forced us to minimize the pressure drop in the prototype. Rick's experience with suction systems at IRobot was leveraged and we calculated that any restriction less than approximately .5 inch inner diameter would exceed a target 2.5 Kpa line pressure drop. We confirmed this to be true using a simple test. We decided to not use any small inner diameter fitting and used an off-the-shelf vacuum fitting, the provided 9 foot vacuum hose, and a modified suction cup to create the prototype. Rick affixed the suction cup to the fitting with epoxy which held firmly during all our testing. We were able to save hundreds of dollars on the prototype and now have a prototype we feel will work during the competition.

3. Teamwork

Abhishek and I worked on the Kinect integration, on the PR2 teleoperation, and briefly on the PR2 navigation. Feroze and I worked on the SMACH integration, debugging ROS and Linux problems, and the system setup on the workstation. Abhishek, Rick and I had some fun together making the PR2 teleoperation videos. Rick and Lekha worked together on the perception system and we now have a rough clustering perception algorithm working using PCL and OpenCV. We all worked with Lekha to create the lab demo for the MRSD class and to present to our sponsor who provided many of the figures provided here. Together, our efforts amounted to meeting the goals we presented last week but just barely. The time required to revert our system to Ubuntu 12:04 and ROS Groovy were not taken into

account but we were able to reallocate our time and came together to achieve success.

4. Plans

Our goals for next week are shown below broken down by subsystem.

Suction

- Find impeller system to use in final build (Rick)
- Iterate upon prototype suction gripper with focus on build quality (Alex)
- Design of Electronics for suction Gripper (Feroze, Abhishek)

Perception

- Design algorithm to filter out shelf from depth data
- Incorporate shelf content knowledge into color based clustering

Platform

- Command the arm inside the state controller (Feroze)
- Move actual PR2 arm using Inverse Kinematics action (Feroze)
- Programmatically command the base to move in simulation (Abhishek)
- Understand tf transform tree (Alex)

I plan to focus on creating several final designs for the suction gripper and on improving the software state machine to pass ROS tf userdata to the appropriate nodes. Rick will select the vacuum impeller system and continue to refine the perception algorithm with Lekha with the goal of filtering out the shelf from the kinect2 data. Abhishek will command the PR2 base in simulation and work on integrating that with the initial SMACH controller and support the suction system electronics and PCB design. Feroze will refine the arm control planning and integration with the state controller and lead the suction electronics and PCB design.