ILR #4
Amazon Picking Challenge

Michael Beck
November 11th, 2016

Team E
Michael Beck
Akshay Bhagat
Matthew Lauer
Che-Yen Lu
Jin Zhu

Individual Progress

My primary responsibility for this week was to draft a final CAD model for the 1 DOF suction gripper. In addition to that I also ended up working with Matt to troubleshoot planning executions with the UR5, and I drafted a conceptual design for a new Pod to reflect the change in the APC rules. Akshay assisted my 1 DOF design by helping me select readily available hardware and by discussing various fabrication techniques.

Final CAD Model for 1 DOF Gripper

A continual challenge in the 1 DOF gripper design has been attempting to find a more suitable vacuum than the shop vac that was used for the competition last year. The sizing of the vacuum and tubing directly correlate to the gripper mount design, and in this sense the final design has been continually put off while shopping for vacuums. Myself and Akshay spoke with Chuck Whittaker and he recommended making something that is perhaps bigger and clunkier than desired to start and working our way down to something more refined later. With that in mind I settled on a design that I hope can simply scale down without major changes for when a suitable vacuum is found, and will use the shop vac in the meantime.

The design can be seen in Figure 1. It is using an aluminum U-channel as a frame to mount the pivoting suction head and the linear actuator (it will likely also support the camera for our system, but this is undecided so far). Vacuum tubing will run through the channel to the suction head, which will be strapped to the inside of the channel through the use of ties or other similar methods. Cuts are made into both sides of the U-channel where possible in order to reduce the design's weight. The linkages for the linear actuator are to be custom fabricated using a composite and a laser cutter or to be made out of aluminum on the mill. The mount for the actuator will be 3D-printed and bolted to the U-channel. The suction head will also be 3D printed (see figure 2 for the first low in-fill print) and has been designed to be printable without requiring the use of support material in the printer. The suction head pivots through the use of shoulder bolts and bushings purchased on McMaster-Carr. The frame mounts to the UR5 by being bolted to a cross shaped 3D-printed part which has a bolt pattern to match the UR5 mount.

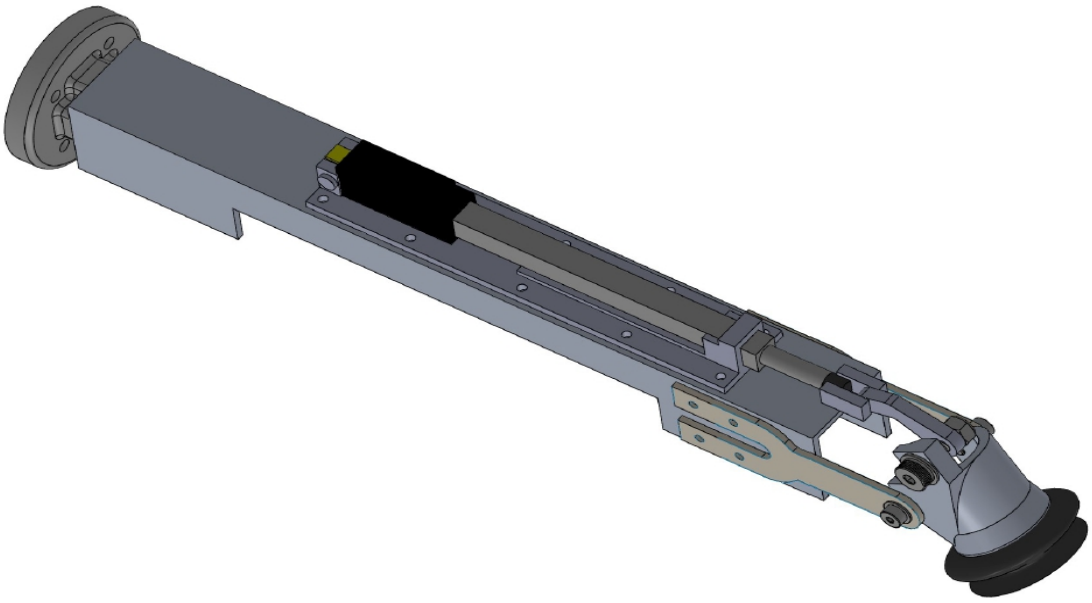

Figure 1: Final CAD model for 1 DOF suction gripper prototype.

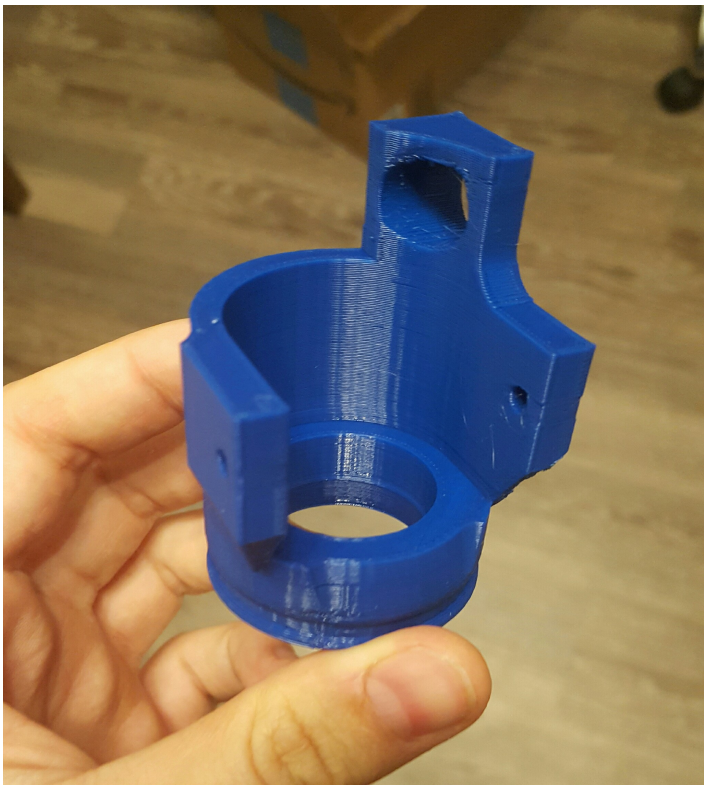

Figure 2: Initial low-infill print for the prototype suction head.

APC 2017 Pod Conceptual Design and CAD

The new rule list for the APC 2017 challenge requires that each team design their own storage system, which has been referred to in past challenges as the pod. The rules outline maximum volumes and working areas that the pod can occupy, as well as a maximum and minimum number of bins that it may have. Any sort of actuator is banned from being used in the design.

The first design draft can be seen in Figure 3 (the blue and red rectangular boxes represent challenge items to be picked). This initial design utilizes the maximum amount of volume allowed for the pod (5000 cm^2 x 125 cm), as well as the maximum number of bins (10). The pod features five drawers which can be opened by the robot easily by utilizing the linear actuator we have purchased from Festo (the robot will grip the drawer and then simply move backward or forward in the same configuration on the actuator in order to open or close a drawer). Drawers allow the robot to pick downward into each bin, making planning and grasping less challenging than having to reach inside occluded spaces. Each drawer has been subdivided into two bins. The lowest drawer is designed such that it has a height 1 cm greater than the maximum possible item height allowable in the challenge as specified by the rules. The next three bins have been designed to hold items half as tall, and the top bin has been designed to hold items one quarter as tall. These ratios are based on assumed proportions of items, and may likely change after receiving the official item list from Amazon. Each drawer features an april tag to help the arm localize the drawer and find the appropriate gripping surface. The internal walls of each drawer have been colored green to allow for easy segmentation of vision algorithms when identifying and localizing items.

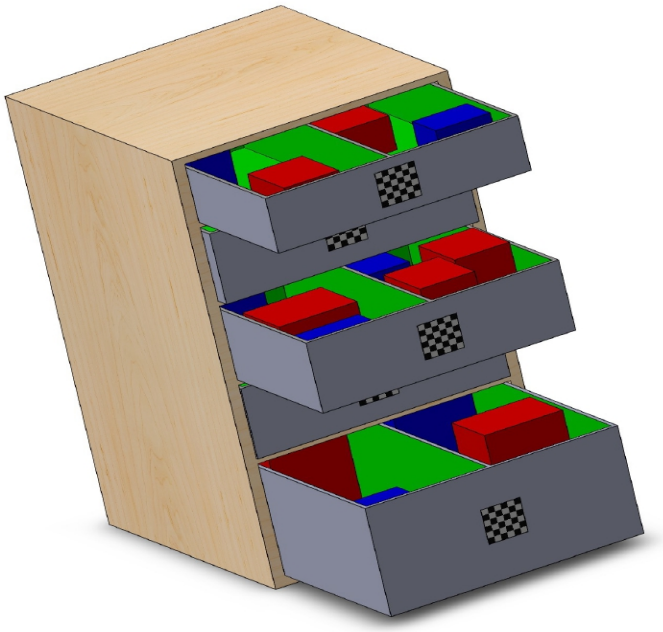

Figure 3: Conceptual design for the pod.

This design was reviewed with Venkat and Rick. Everyone came to a consensus that parallel drawers would be preferable to stacked ones, however this is difficult to accomplish with area constraints given for the contest without giving up a lot of volume which is needed to store all the items for the competition. This is a very early design and will hopefully be iterated and refined many more times in the coming months.

Challenges

Finding Appropriate Hardware for the 1 DOF

Finding suitable hardware for the 1 DOF gripper has been a continuous challenge. Industry suppliers are very hesitant to tackle this issue, as most companies who are involved with suction gripping work within highly defined environments (which is more or less the antithesis of our situation). In many situations we are looking for very small dimensions of components in order to keep a slim profile, however this desire limits our ability to find the required hardware locally. The peril of this situation is that buying online doesn't allow for inspection of the materials. This has manifested once already in buying a hose that has ribbing which exceeds are constraints for the gripper design.

I think I am going to being shifting my focus from finding tailored resources for this design to trying to find outside-of-the-box solutions, possibly by retrofitting unconventional components. I am hoping that by exploring labs on campus and researching other mechanisms which require hosing and small fasteners I may come to a solution. I am also waiting on a couple companies such as RAF to see if any of their distributors have any insights, and they are keeping in touch with me every few days or so with updates.

Teamwork

Matt and I worked together to troubleshoot strange behavior in the planning scene. After tinkering with joint limits on the UR5 for the last three wrist joints we finally started seeing some straightforward path planning, and we were able to cleanly get the robot to transition between each bin.

Leo, Akshay, and Jin all worked together to get Caffe running and to have it start identifying items from last year's competition. They were also able to fix the driver for our Intel RealSense.

Future Plans

Moving forward this week I have two goals. I intend to have the prototype for the 1 DOF constructed, hopefully with a suitable vacuum hose integrated (otherwise the system frame will only be constructed with validation that the suction head and mounting mechanisms work as expected). I also intend to work with Matt to start to create a planning simulation to be featured in our application for the 2017 APC, which will likely involve having the virtual robot interact with a shelf like the one I designed above.