ILR #2
Amazon Picking Challenge

Michael Beck, Team E
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Individual Progress

My primary responsibilities for this week were to generate CAD models for a prototype gripper, to research suction generation mechanisms, and to work on the PCB board for our system. In addition to that I also ended up working with a representative at RAF Automation to secure a linear base for our platform.

1-DOF Suction Gripper

A 1-DOF suction gripper has proven successful for many teams at the Amazon Picking Challenge. Due to this as a team we decided we should have a working 1-DOF suction gripper available as a potential final design choice. This allows our team to begin testing our platform with a viable gripper while we are waiting for Amazon to release the item list for next year's challenge.

The main influence I've chosen for the gripper design is the winning team from last year's challenge, Delft. Delft placed their suction head on a pivot, and then used a linear actuator in conjunction with a serial linkage to cause the head to pivot from an axial position to the end effector direction into a 90 degree bend (1). I am attempting to simplify Delft's design however, as we are not incorporating the additional two-finger gripper they had into our system, so I chose instead to put the actuator on the top of our end effector as to minimize clearance issues on the sides and attempt to create a symmetric profile. I am also looking to take a suggestion from last year's team into consideration, which is to have the end effector be co-axial with the robot wrist in order to simplify planning computation. To that end I am playing with a slotted adapter design, in which a mounting plate will bolt to the robot wrist and the end effector will slide into the mount and then be bolted to it to maintain its position. Solidworks mockups are shown in Figures 1 and 2:

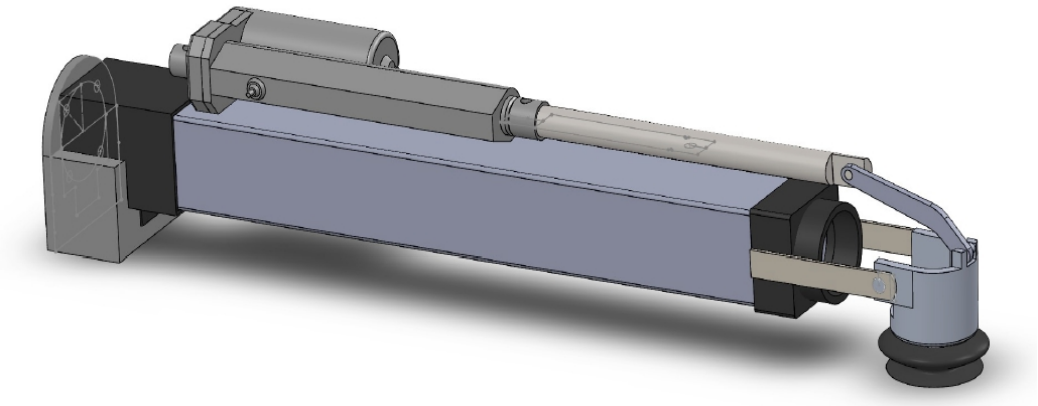

Figure 1: Draft end effector in the 90 degree bend position.

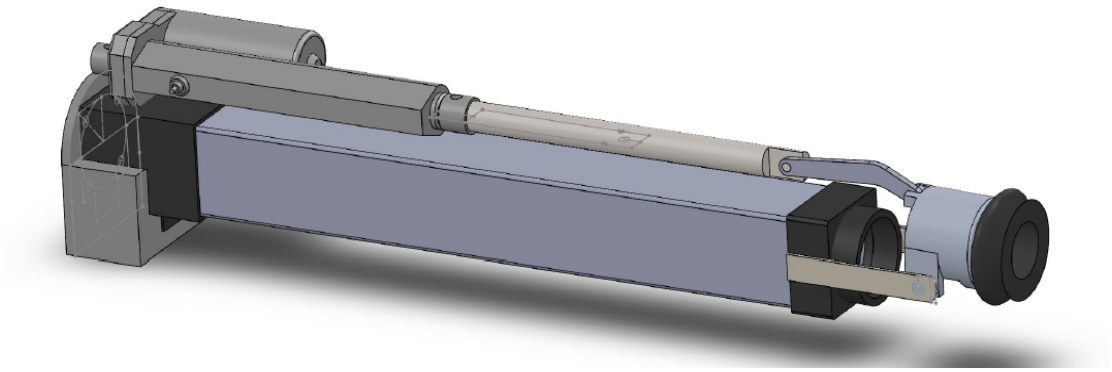

Figure 2: Draft end effector in the co-axial position.

Figures 1 and 2 feature a linear actuator that was found on the McMaster-Carr website, however since that time a better replacement has been found to be available in the lab, specifically the Firgelli L16-140. The Firgelli offers a slimmer profile while still meeting our force requirements in order to push and pull the suction head of the gripper.

In addition to this design a cable system in conjunction with a torsion spring is being considered. This was suggested by Alex, and could possibly be a viable way to create a system more similar to team Nimbro's from last year, in which the movement mechanisms for the suction head were internal to the end effector body (2).

Suction Generation Mechanisms

The goal while researching suction mechanisms has been mainly address to concerns from the last team's experience with the shop vac setup, which are the decibel level of the shop vac and its operating pressure. The shop vac performs well enough to compete, however it is unable to generate enough head to lift the heavier items in the competition such as the 3kg weight, and was much louder than some other team's mechanisms to the point of causing discomfort during operation of the system.

A major focus for me this past week was to attempt to develop a better operating understanding of what would make a vacuum successful. To that extent I was able to find some literature that helps to generate specs for suction cups and industry vacuum generators, specifically for the application of lifting flat plates through suction based on the plate weight, material type, and a desired factor of safety (3). Unfortunately this methodology does not completely fit with our application due to the non-rigid nature and radial surfaces of many of the items that last year's competition featured. It does however allow me to having an understanding of how this type of hardware is spec'd and what type of language is used, and I have accordingly begun communications with a Festo distributor at RAF Automation, with the goal of working with their engineers to see if we can find a more elegant design solution than a commercial vacuum system such as the shop vac.

I am still keeping my eye out for other systems that will meet our needs besides a vacuum generator, and am taking suggestions from last year's team into consideration including mechanisms that they observed were used by other teams during their competition.

Linearly-Actuated Base

A full system for a linearly-actuated base has been ordered, including the motor, controller, and connection cables. I have been in communication with RAF Automation and they have been working with me to reduce the pricing for this system for the past few weeks, and we decided as a team that RAF's latest proposed pricing of roughly ~$2500 was acceptable in consideration of our budget. All parts for the base are expected to arrive in the next 1-4 weeks. The discounted hardware is all from Festo, and I am continuing to keep in contact with them in hopes that we can continue to receive discounted components as necessary or possibly receive some of their grippers to test with as a loan for the competition time frame.

Challenges

End Effector Body w/ Non-rigid Connections and Vacuum Specs

There is an ongoing challenge with vacuum selections where flow rate and pressure generation for commercial vacuums have drastic trade offs. For example the shop vac used by last years team has a very high air flow rate and relatively low pressure, but alternatives I've found with higher pressures have flow rates that scale down at an exponential rate. I have not found a satisfactory compromise yet and am hoping communications with Festo engineers will prove fruitful for an industry vacuum generator that suits our needs. In the meantime I am continuing to look at other options.

In addition to the vacuum challenges I am also struggling with sizing of the end effector. A 1-DOF suction mechanism requires flexible tubing, which is generally circular. This means last year's gripper mechanism can't be adapted to include the extra degree of freedom, as their frame is rectangular. I am looking into molding my own tubing to adapt to last year's framing, as I want to have it as a backup since the amount of pressure generation they were producing has already been verified as being viable.

Teamwork

Matt and I worked together this week to draft the specs for our project PCB. We determined the power needs and a rough layout based on a 1-DOF suction system using last year's shop vac. This included powering an arduino, the linear actuator tied to an H-bridge, and a 120VAC relay. All other components are expected to run off directly from

an outlet plug, including the stepper motor for the linear base.

Aside from the PCB most of the work for our project tasks has been done individually, or in the case of our Vision portion by Akshay and Jin in tandem. There have been some exceptions, such as Leo providing support to Matt or Akshay with software issues, or myself providing feedback to Leo on the software architecture, but we primarily we have had our own tasks. This separation has been working to an extent, but we are having issues where some parts of the project seem to be developing quicker than others. I am beginning to propose to the team that we start having some more overlap with responsibilities, at least to the extent of determining weekly tasks and increasing communication around any challenges team members are facing. Akshay has also pushed the team to adapt to SCRUM techniques through the Trello website, which may help to keep our team members on track.

Future Plans

Moving forward this week I have a few goals. I intend to keep in contact with RAF in order to evaluate vacuum generators, and to keep looking for commercial options that fit our needs. I also plan on creating the mounted adapter for the arm so that the previous year's end effector and future end effector designs can be co-axial to the arm wrist, and to get the previous year's end effector mounted and operating on our UR5.

References

1. Amazon Picking Challenge 2016 - Team Delft picking. https://www.youtube.com/watch?v=3KlzVWxomqs. Sept 15th, 2016.

2. Team NimbRo at Amazon Picking Challenge 2016. https://www.youtube.com/watch?v=7Dlt8T3s3HY. Sept 15th, 2016.

3. Example of Vacuum Calculations. Camozzi Product Catalogue. http://www.avs-yhtiot.fi/sites/default/files/pdf/7.01.05_alipaine_ohje.pdf. Accessed Oct 18th, 2016.