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Progress Review 1

Individual Lab Report #2

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Team D: Team HARP (Human Assistive Robotic Picker)
Teammates: Alex Brinkman, Feroze Naina, Lekha Mohan, Rick Shanor

I. Individual Progress

For the Progress Review 1, I was responsible for developing a 'Game Strategy' for Amazon Picking Challenge (APC) 2016. The intent behind this was to carry out a detailed study on Amazon Picking challenge 2015, to understand rules of the competition, to analyze various team's performance, and understand different technologies and system design decisions. I presented the complete analysis to Professor Maxim on October 22, 2015.

I started with understanding the challenge details from the official Amazon Picking Challenge 2015 website. The shelf system consists of a steel and cardboard structure seen in figure below (Figure 1). Only a single face of the shelf was presented to the teams, stocking of the items was changed pseudo-randomly between attempts. Only a subset of 12 bins on the shelf face was used. The subset was a patch of the shelf face covering bins inside a roughly 1 meter x 1 meter area. The base of the first shelf from the floor was at a height of approximately 0.78 meters [1].

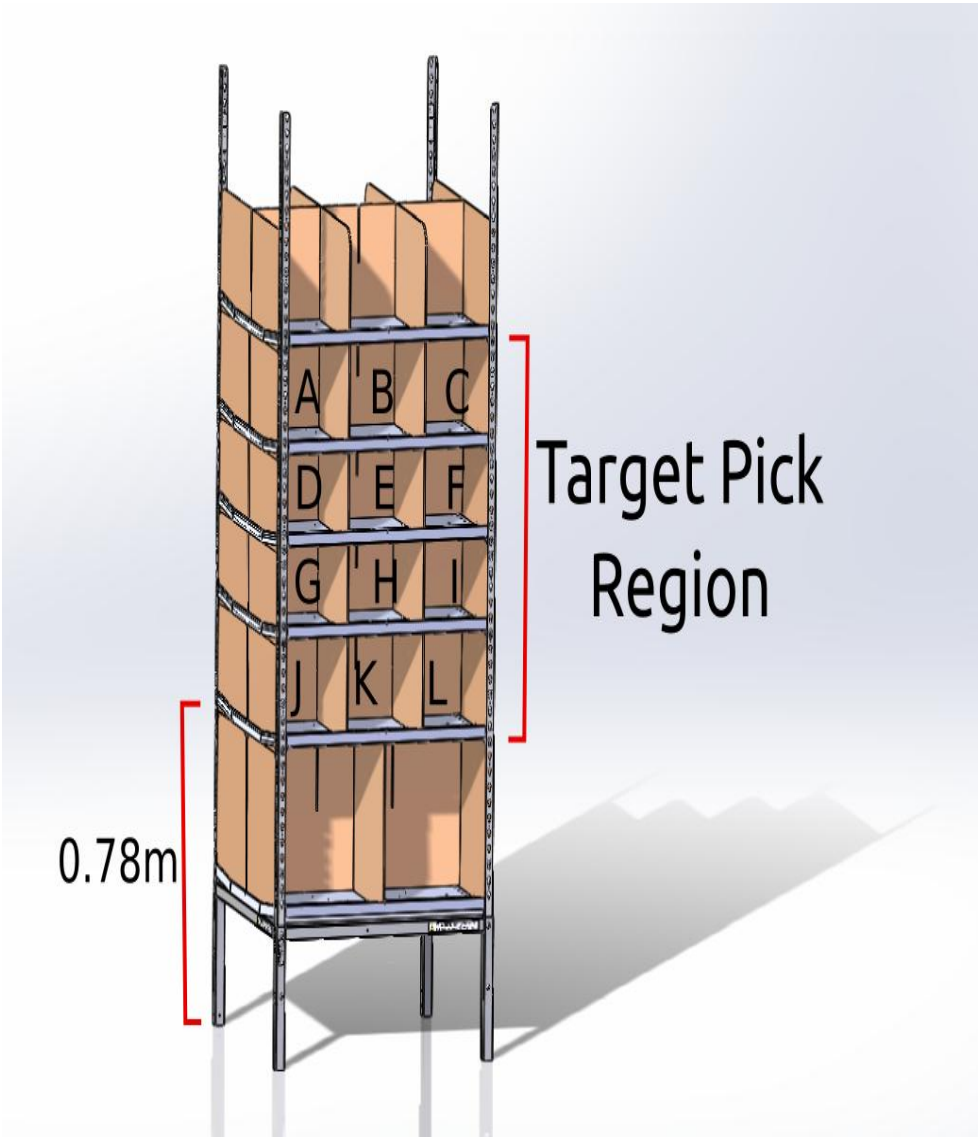

Figure 1: Representation of shelf used at competition
(Image courtesy: http://amazonpickingchallenge.org/details.shtml)

After this I analyzed the item dictionary from last year, a subset of these items were stocked inside the shelf bins. The image below shows the proper form (including packaging) of these items (Figure 2). We are considering the same item dictionary for our preliminary testing, until Amazon releases the official rules for this year. We procured some items from this dictionary to start testing our gripper prototype. I plan to procure the remaining items this weekend.

Figure 2: Item Dictionary, Amazon Picking Challenge 2015
(Image courtesy: http://amazonpickingchallenge.org/details.shtml)

After this I analyzed the scoring parameters used last year. This is shown in the figure below (Figure 3). I will be working on designing the algorithm to develop the item plan in a way to score maximum points and analyzing.

Moving a target item from a multi-item shelf bin into the order bin	+20 points
Moving a target item from a double-item shelf bin into the order bin	+15 points
Moving a target item from a single-item shelf bin into the order bin	+10 points
Target Object Bonus	+(0 to 3) points
Moving a non-target item out of a shelf bin (and not replacing it in the same bin)	-12 points
Damaging any item or packaging	-5 points
Dropping a target item from a height above 0.3 meters	-3 points

Figure 3: Scoring parameters for Amazon Picking Challenge 2015
(Image courtesy: http://amazonpickingchallenge.org/details.shtml)

Finally, I worked on gathering whatever information I could with respect to each team that participated in APC 2015. I am providing information about 6 teams below:

1) Team RBO (Rank 1: 148 points)
   Video URL: https://youtu.be/DuFtwpxQnFI
   Platform: WAM Arm (Barrett Technology) + Mobile Base.
   End-Effecter: Suction.
   Successfully picked and dropped (in the object bin) around 11 objects in ~20 minutes. Failed to grasp only 2 objects: (i) Meshed pencil cup, (ii) Probably a Cheese-it box (Failed while trying to grasp the object sideways, ended up dropping it).

2) Team MIT (Rank 2: 88 points)
   Video URL: https://youtu.be/ffxn-bkIqxs
   Platform: Industrial ABB 1600ID Arm, no Mobile Base [2].
   End-Effecter: Designed a custom end-effector from aviation-grade aluminium. At the outer-most end of bottom finger tip is a spatula-like finger nail, can scoop objects from underneath, or grasp objects that are flush against a shelf wall. On the top finger, there is suction. 7 motion primitives defined: grasping, suction down, scooping, toppling, push-rotate, etc.
   Did not drop/fail to pick any objects and used the multiple grasping options defined. Scooping objects from underneath was very effective. Only drawback seemed that the huge arm was not fast enough. Also, for perception, team MIT statically mounted two Microsoft Kinect2 cameras to the left and right of the robot, and one Intel Realsense camera on the robot arm, close to gripper. To classify and find the

pose of objects, they utilized a software package by a startup company - Capsen Robotics. Capsen Robotics' software receives pre-processed data from cameras and instructions on what objects to look for, it returns the position and orientation of the target objects.

3) Team Grizzly (Rank 3: 35 points)
   Video URL: https://youtu.be/M1eDITfH0DM
   Platform: Baxter with Dataspeed Inc mobile base [3].
   End-Effecter: 2-Finger gripper.
   Picked and placed 3 objects.

4) Team CVAP (Rank 13: 9 points)
   Video URL: https://youtu.be/KZ02c49p43g
   Platform: PR2 (Probably the only team).
   End-Effecter: 2-Finger parallel clipper.
   I could not gather information about their final performance at the competition. I am contacting representatives from this team to gather more information. We are particularly interested in getting in touch with this team to gather as much information as we can.

5) Team Research Center E. Piaggio
   Video URL: https://www.youtube.com/watch?v=21C_Mb7ALTQ
   Platform: Mechanical Gantry, no mobile base.
   End-Effecter: 5 Finger, human hand like gripper (soft hand).
   Simple solution to the problem, can be very effective with a suction based end-effector. For perception the team used a single Kinect close to end-effector. One drawback that I could think of is portability and robustness of the system as a whole, because assembling the whole system at the competition venue can be problematic.

6) Team Applied Robotics
   Video URL: https://youtu.be/j_x1-7i_dXY
   Platform: Universal Robotics UR5 Arm, no mobile base [4].
   End-Effector: Suction based gripper.
   Team used a single Kinect close to end-effector. I found their system to be most efficient, but this team could not perform well at the competition venue because of technical failures.

Based on this study, I got to know the broad range of hardware and assortment of technologies used at the competition venue. I also understood what mistakes teams did, so that we shall not repeat these for APC 2016. We will use this study as a reference for system design decisions throughout the course of this project.

Besides this, I reviewed the software specification and helped Alex and Feroze with coding the skeleton of our software system in ROS.

II. Challenges

The first challenge that I faced this week was that I could not find much information on PR2 with respect to APC. There was just 1 team that used PR2 as a platform and they did not fare well in the competition. This puts us in a difficult position because we have limited information for the platform that we are using. As mentioned earlier, I am trying to contact the representative from Team CVAP (APC 2015) to gather information on PR2's performance, specifically the challenges they faced while trying to accomplish this task. Besides, we are also interested in understanding what difficulties Team CVAP faced working with PR2 provided at the competition venue, re-integrating the system and re-calibrating sensors.

Other minor difficulty I faced during last week was to find a common time to collaborate with Lekha and work on some part of this task. It was the week of two midterm examinations and multiple deadlines. But, we overcame this issue with proper planning and division of tasks. We discussed things offline and were able to collaborate on this, without meeting in person.

III. Teamwork

As a team we again followed a very structured approach to divide the task within ourselves.

Alex: Worked on creating the software specification of our system. Besides this he helped Rick with preliminary suction design.
Feroze: Worked on defining the software specification with Alex and later worked on coding the initial code skeleton in ROS.
Lekha: Lekha worked on developing the algorithm for feature matching for items from APC 2015 item dictionary.
Rick: Worked on Preliminary Suction design and helped Lekha with feature matching algorithm.
Abhishek: I had my complete focus on researching the history of APC 2015.

Besides, we all worked together to finalize our work breakdown structure and schedule for this semester. We also listed down tentative dates for tasks to be accomplished during next semester.

IV. Future Plans

For Progress Review 2, my primary responsibility is to work on tele-operating PR2. Professor Maxim wants us to demonstrate our suction gripper to grasp objects from shelves

tele-operating PR2. This task will validate our suction design and help us get familiar to operating PR2. Besides this, I want to focus on navigation planning and execution for PR2. I want to get familiar with the move_base package in ROS. I plan to spend some time going through the tutorials available on PR2 navigation planning.

V. References

1) http://amazonpickingchallenge.org/index.shtml

2) https://mcube.mit.edu/blog/summary-team-mits-participation-amazon-picking-challenge

3) http://www.oakland.edu/view_news.aspx?nid=12261

4) http://appliedrobotics.blogspot.com/