# INDIVIDUAL PROGRESS REPORT

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Team D: HARP

Teammates: Alex Brinkman, Rick Shanor, Abhishek Bhatia, Feroze Naina

ILR04

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## I. Individual Progress:

My primary role for the past week's project was to create a vision pipeline along with Rick Shanor and Abhishek Bhatia. The pipeline is as represented below: (Fig 1)

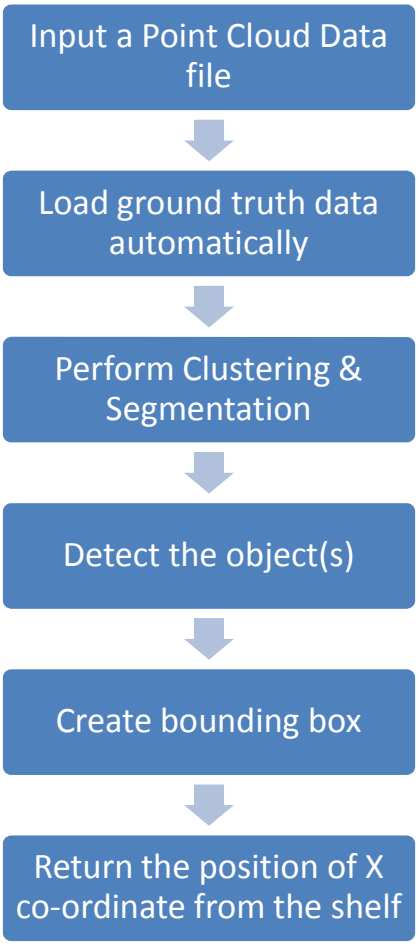


Fig 1. Vision Pipeline

We used Rutger's database(over 1000 images) to test our perception algorithm. We extensively used the Point Cloud Library documentation for algorithms. The vision pipeline has a record of 56% accuracy. The reason for failing at certain images and future steps taken to make it robust are discussed below. A large modification we did to the code was to remove the shelf from the point cloud, so that, we don't have any redundant data that might affect the algorithm. Rick made modification such that any point cloud that exceeds the threshold of a distance along the Z-axis, should be converted to "Nan". The "Nan" values were then ignored using the "quiet_nan()" function provided by the Point Cloud Library. The cloud was then downsampled and segmented , taking the minimum and maximum value of detected objects along each axis and to construct bounding box around them.

## Iterative Close Point Algorithm:

For Item detection, Iterative Close Point algorithm was implemented. It is an algorithm that is used to reduce the difference between two clouds of points. One cloud is fixed, while other cloud is continuously transformed until the best match is obtained. For every source point cloud, using mean square error, the reference cloud is transformed and closest match is obtained. This process runs for several iterations until the least distance is obtained. We ran the test pipeline for over 1000 images to record the test results and the result accuracy obtained was around 56%(Fig 2). Point Cloud Library, though has an extensive list of classes custom made for various functions, it doesn't work for a generic data set. We had to modify our algorithm to get rutger's data set working which was a time consuming, yet, gave a great insight of Point Cloud Library.

Fig 2: The detected object bounded by box

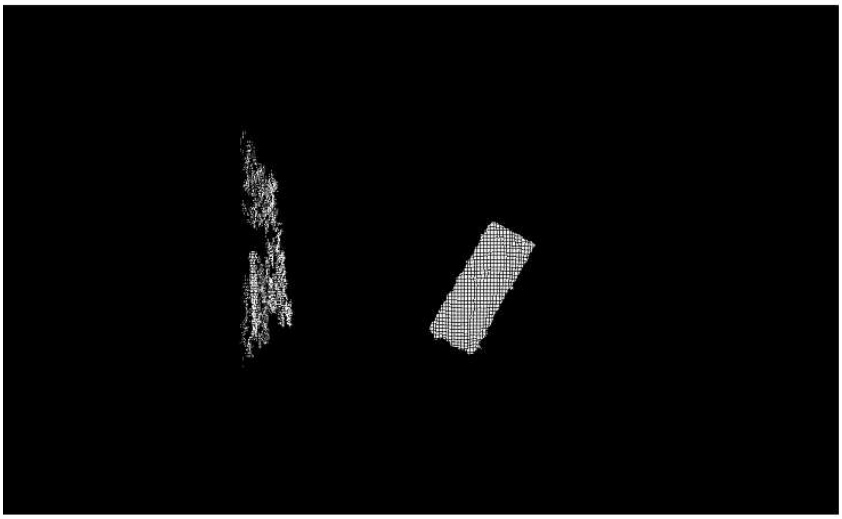

Fig 3: Filtered out shelf point cloud

Fig(3) represents the point cloud data of the shelf filtered out to avoid any of the redundant data. The slice of shelf that we see, is the shelf along the side, which doesn't affect or count in the algorithm.

### Error Analysis:

The kind of errors that we faced :

- Objects being detected where objects are actually not there
- Objects not being undetected
- The x-axis co-ordinate(position of the centroid of the object) of the object not being precise.

I ran an analysis of error and I modified the paramenters of the clustering and segmenting algorithms that we used, for example, downsampling points, radius search for clustering etc.,. I realized that 70% of the errors were not due to the efficiency of the algorithm but clouds not being detected in the first phase. This again implies that our algorithm is not robust enough, and inexperience with PCL and C++ is another cause for this lag. For upcoming weeks, I will be religiously working on improving the accuracy of the algorithm, determining the best grasp position for the object by the PR2 arm and integrating the perception module with the ROS frame work.

### Grasp Position:

Determining the grasp position should be an interesting problem to work on with respect to perception. We need to keep in mind the cases of occlusion, cluttered environment, where the object when grasped, should not move or damage its neighborhood objects. The best grasp position should also not drop the item while fetching it. The suction cup is bent at an angle and hence, the grasping cannot happen at normal to the surface of the object.

## II. **Challenges**

My biggest challenge was integrating sub-parts in the perception algorithm. Though most of the integration was done by Rick, we hadn't agreed upon a common prototype which we did modify later(I realized that it is not a good programming practice). The dataset given by the PCL worked really well for the given algorithm whereas Rutger's database failed. Some of the cloud points that we have now, do not seem to detect certain cloud points. We are working on its accuracy of improving the algorithm and are also trying to capture the live kinect data stream from the kinect cameras. The next step would be to capture the live stream of kinect data and passing it the pipeline.

I am still not clear as to what modifications should I take up to enhance the quality of my output. As I study further about PCL, I am getting a great insight of the library. I should be hopefully be able to tweak the algorithm such that it works on any generic data set

that we input to our pipeline. Given below is a graphical representation stating our accuracy of the algorithm (Fig 3)

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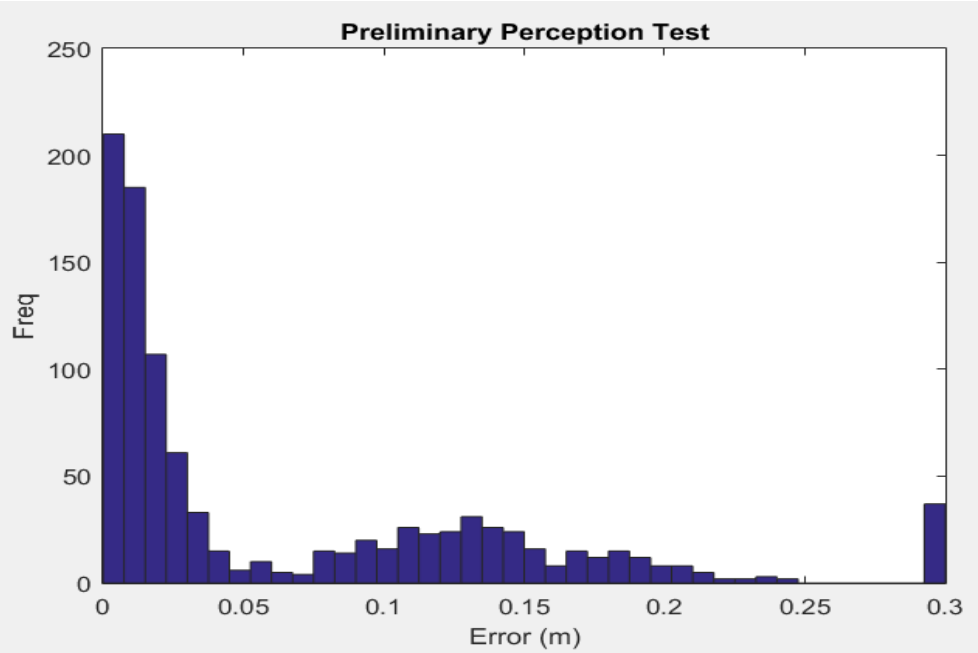


Fig 4. Graph representing our accuracy
Picture Courtesy: Rick Shanor

## III Team Work

We had acquired a new shopvac vacuum cleaner for final suction system and re-iterated the prototype suction gripper design. Rick and Feroze, were working on final PCB design and ordered the required components with extras. Feroze was also working on moving actual PR2 arm using the inverse kinematics, simulating the inverse kinematics arm motion. Alex and Abhishek , were working on the SMACH controller and called the MoveIt planner within the estate machine controller. Alex was able to define the target pose using the movable interactive marker inside rviz. The arm was moved successfully from the target pose to the bin position.

## III Future Plans

With respect to the suction system, our final weekly goal would be to have the final PCB enclosure and create a test circuit with components plugged in for the final system hardware. We are also planning to procure computer for kinect2 and run our vision pipeline and consequent algorithms directly by grabbing real-time data for kinect-2. We will also be giving the position of an object with respect to the camera's frame of reference for grasping. We will also be parallel working on the improving the accuracy of

the algorithms. With respect to platform, we will be demonstrating a simulation that can move base along an axis, move the arm to the center of all the nine shelf bins and then move the arm to the top of the order bin as a proof of concept .