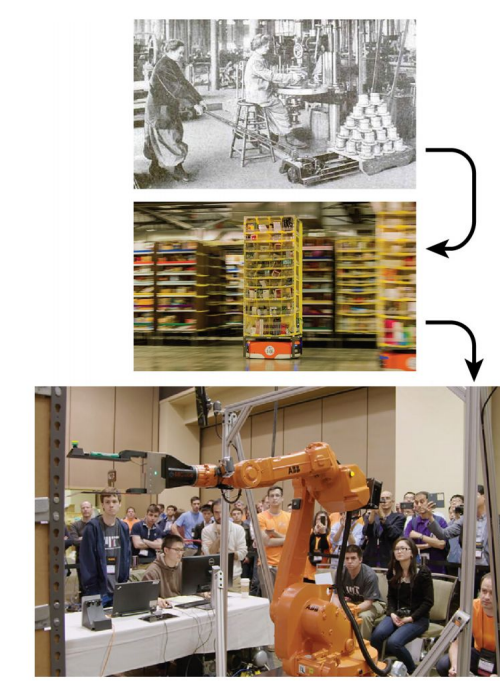


Problem Statement

Picking is the last link remaining to be automated in Amazon warehouse. After 2009, Kiva robots change the face of Amazon warehousing, shelves could be moved to workers without human intervention. However, manpower is needed in order to pick items in designated box with reference to the work order. With our robot, the warehouse operation cost could be reduced.

Team PLAID's objective is to develop an autonomous robot that can pick various objects in a warehouse environment. The system was designed to pick up at least 12 items from the shelf and drop them inside their target totes within 15 minutes and report the items picked.



Use case



Functional Architecture

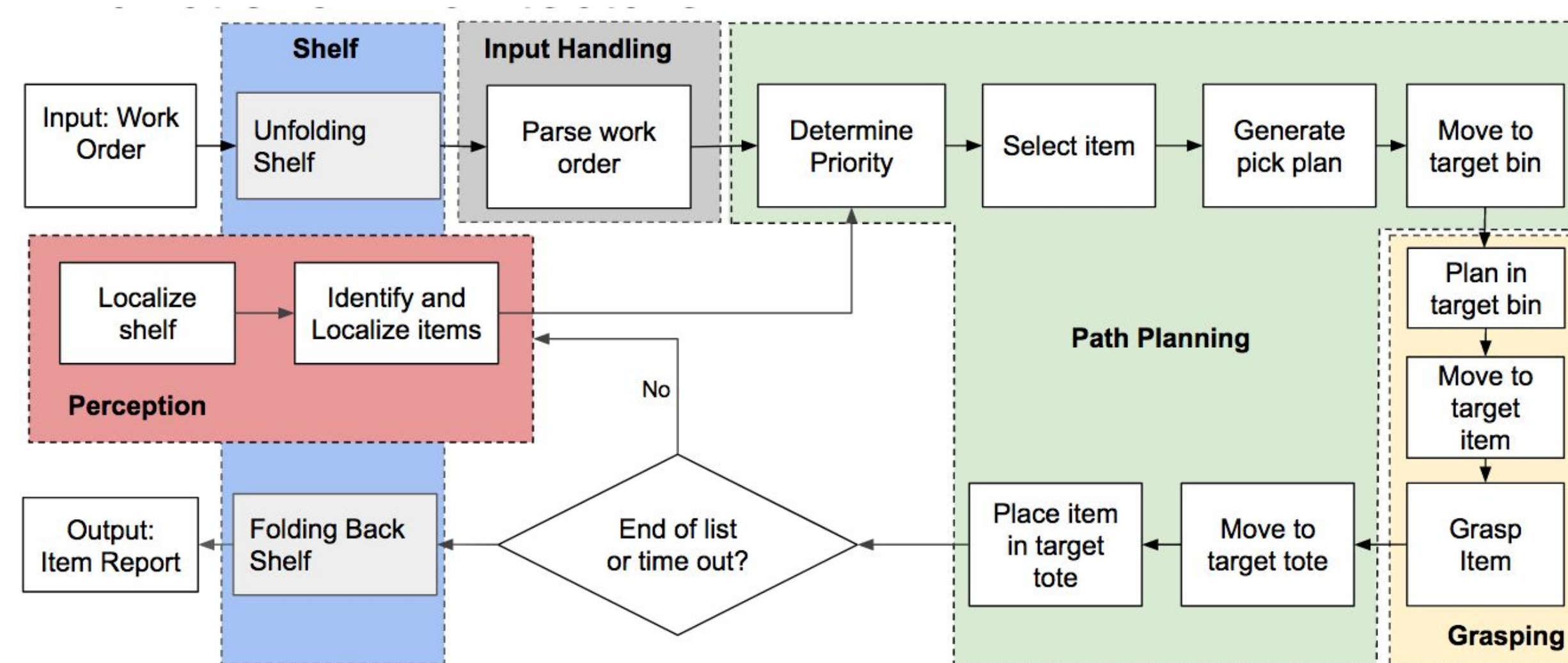
Input Handling: JSON file indicates which items are in which bins

Shelf: Bins on the shelf will be actuated out to position easy for perception and grasping. At the end of task, the bins will be put back to the original positions

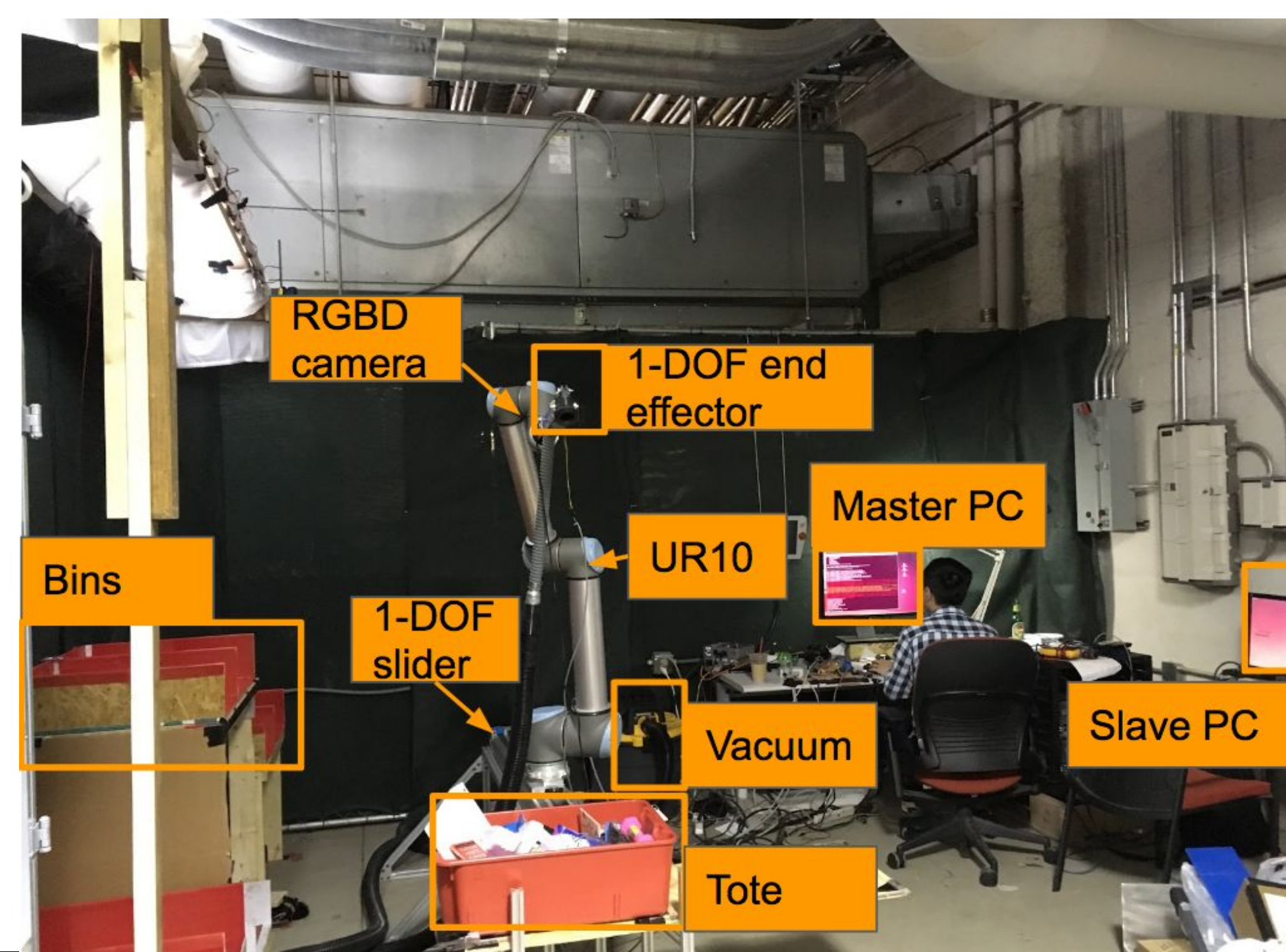
Perception: The RGBD camera will localize the shelf using Apriltags. FCN gives pixelwise labeling for items in each bin. Items Segmented point cloud is used for generation of grasping poses.

Planning: Based on the confidence score from the perception subsystem and the "pickability" of the item, an item priority list is generated. The item on the top of a priority list will be selected and a path to the target bin will be generated. The path will also avoid collisions and entanglement of the vacuum hose

Grasping: The end effector follows the path and moves to the item. Then the end effector will grasp the item, move to tote, and place the item in the tote safely. The 1-DOF gives the vacuum end-effector ability to grasp items of different poses.



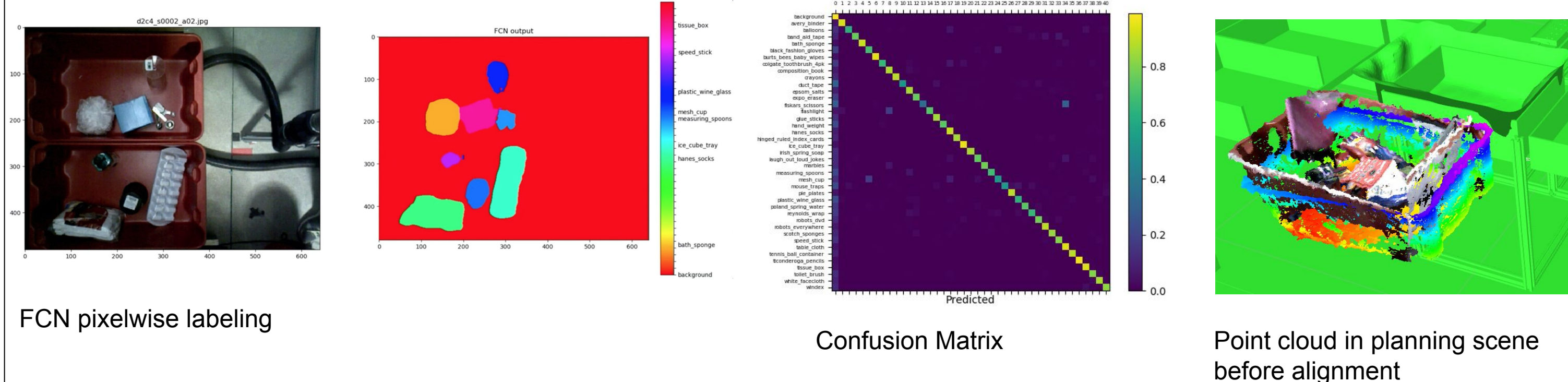
System Hardware



Subsystems

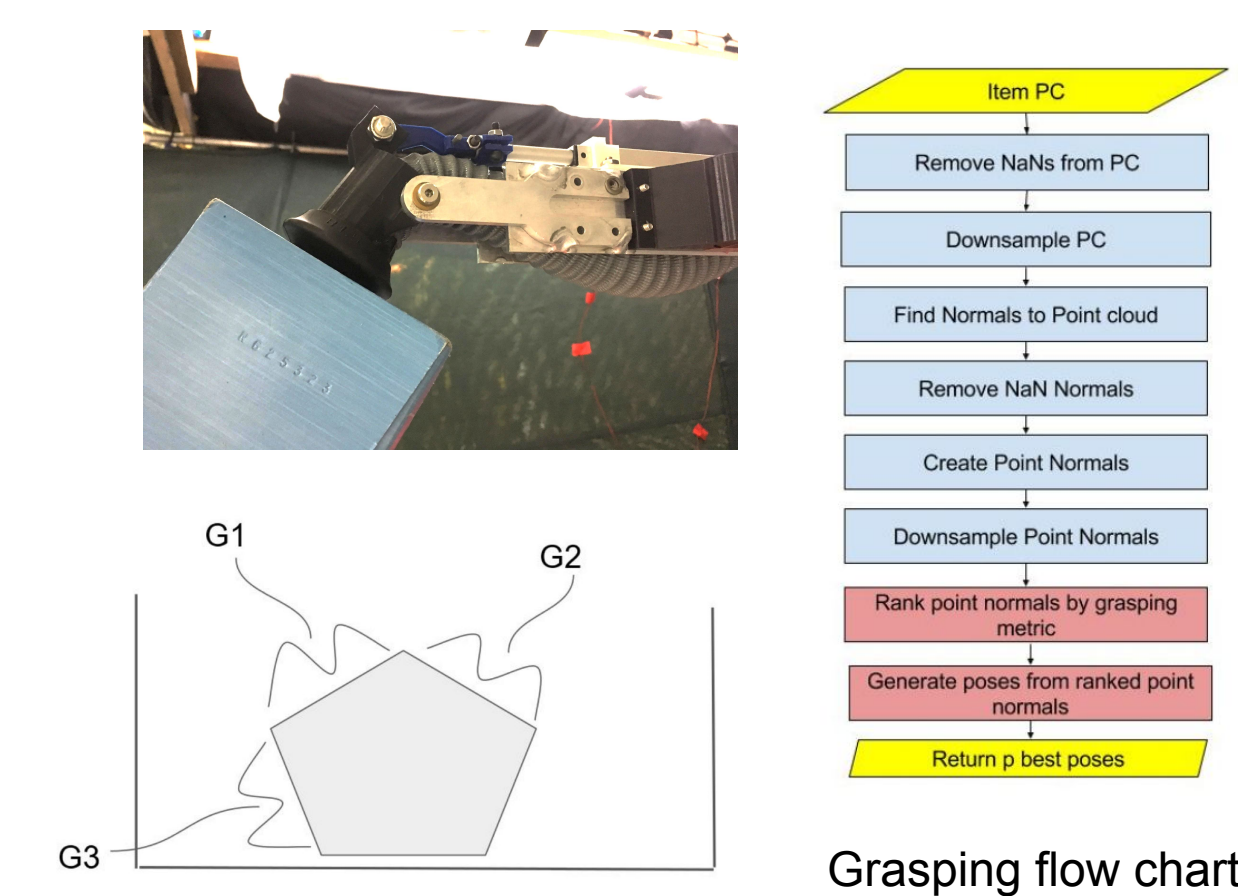
Vision

- FCN generates pixewise labeling
- Item classification result is filtered using JSON file, which indicates which bin contains which items
- Confusion matrix is generated for pixelwise labeling
- AprilTag and ICP are used for localization and point cloud segmentation.
-



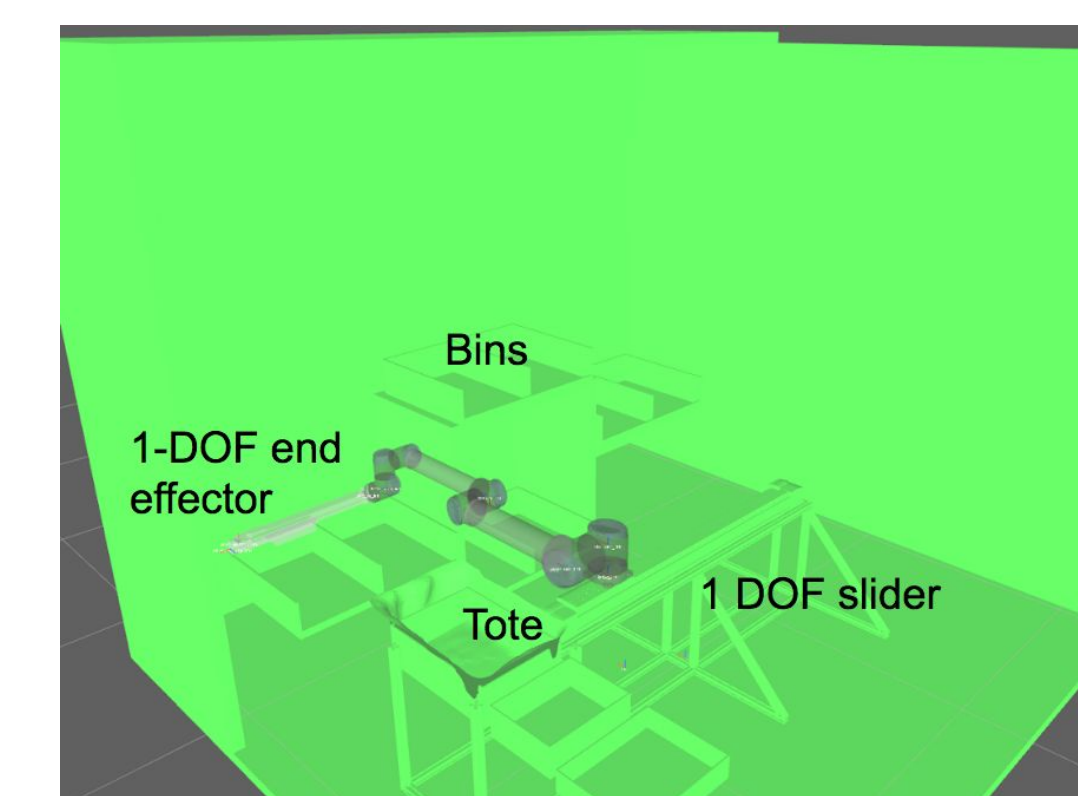
Grasping

- Items are grasped using suction
 - Pressure drop indicates if item is picked
- Segmented point cloud
 - Centroid grasping
 - Priority list based on item identification confidence
 - 1-DOF to get items in cluttered tote
- Vacuum control using pressure



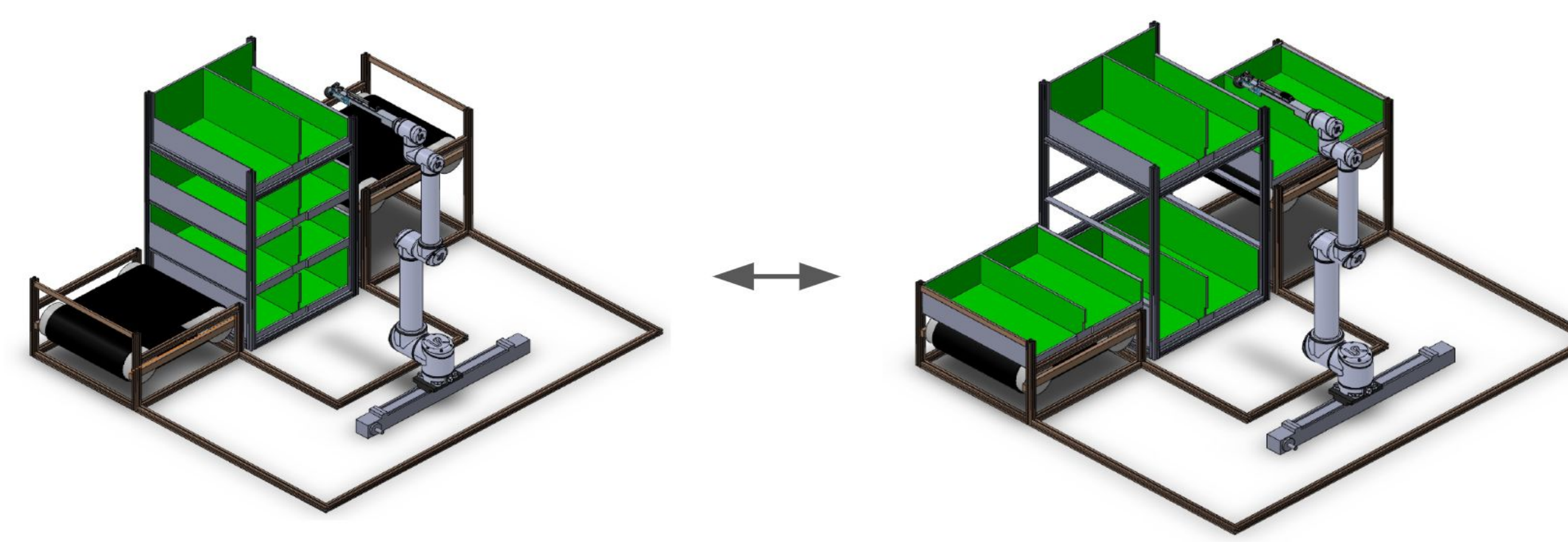
Planning

- Weighted A*
- MovelIt! Motion Planning Framework
- Adding constraint on end effector to prevent tube tangling
- Challenge: Ability to reach all bins:
 - 1 DOF slider
- Collision checking
 - Tote, shelf, slider etc.



Shelf

- Wood shelf prototype
 - Modify to aluminum shelf for competition
- Shielded from ambient lighting



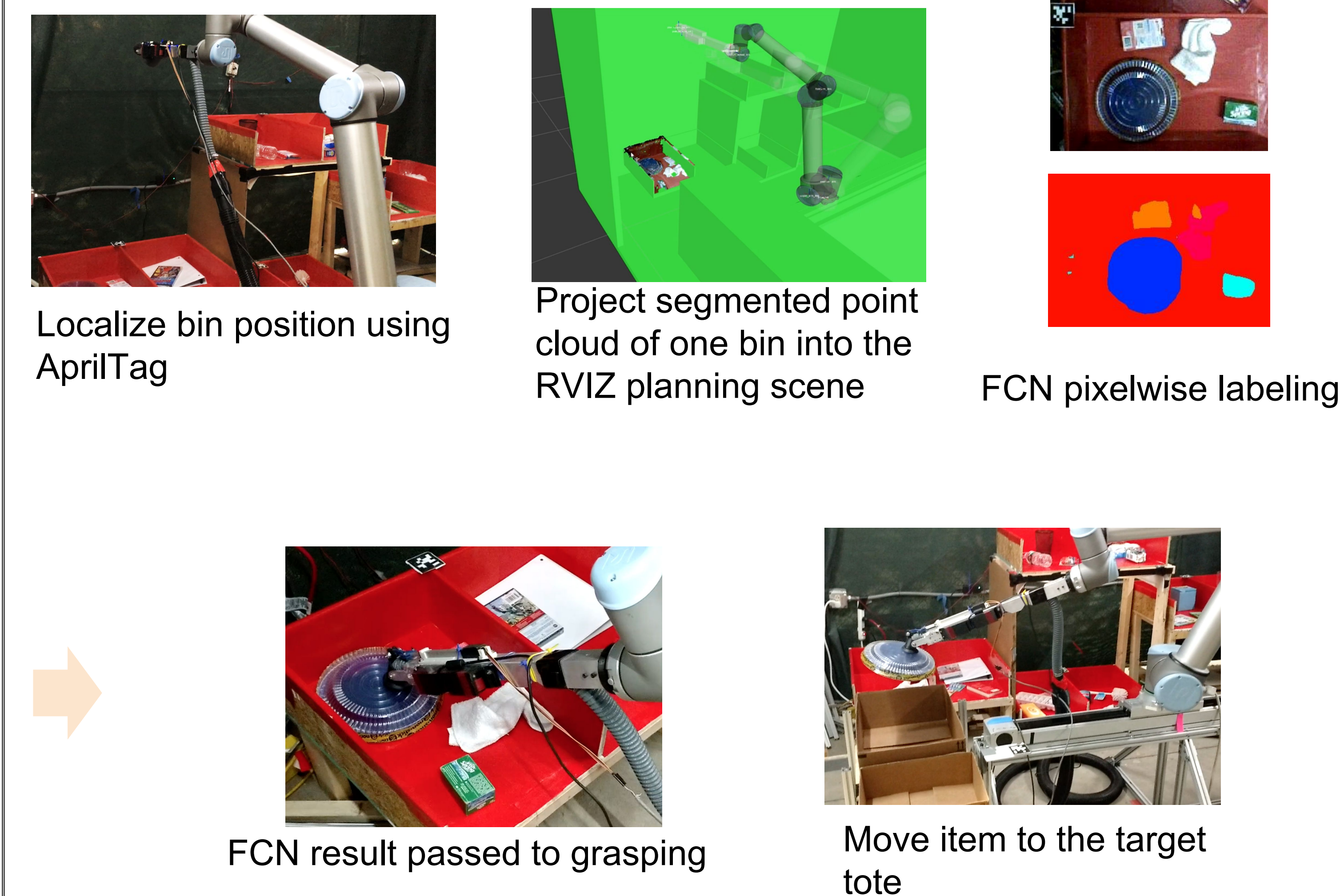
Result

Overall: A total of 4 items were picked in 6 minutes. JSON file report 100% accuracy

Vision: The FCN net operated very well, identifying between 56% to 96% of pixels for all items, even in heavily occluded environments.

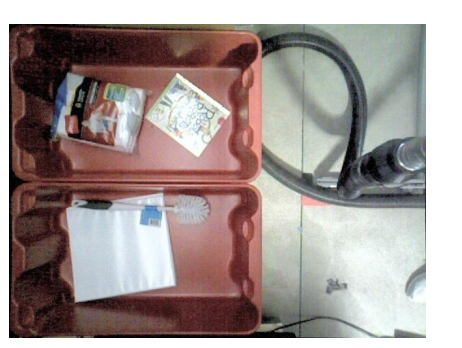
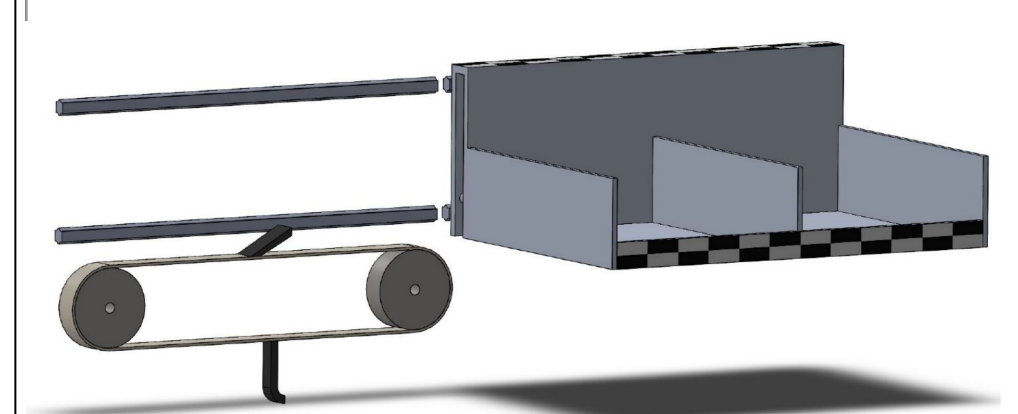
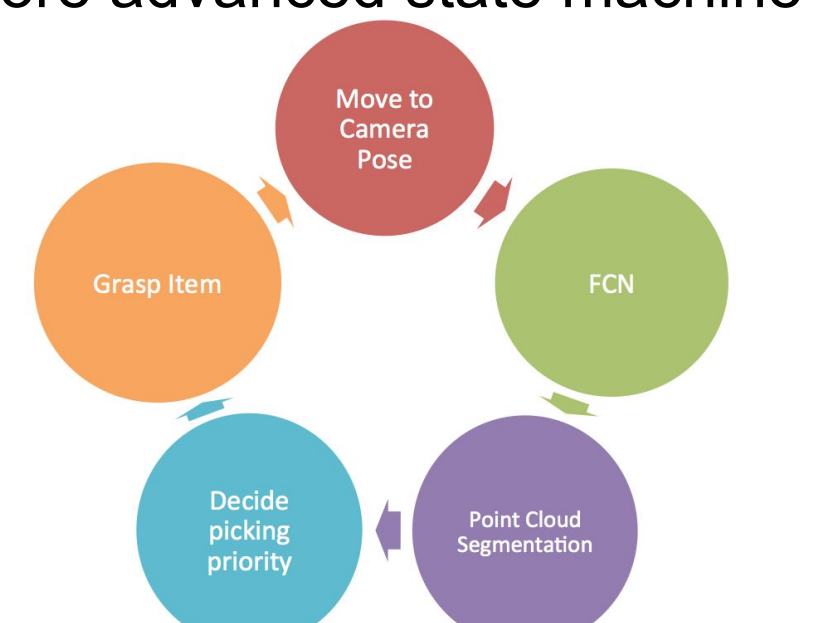
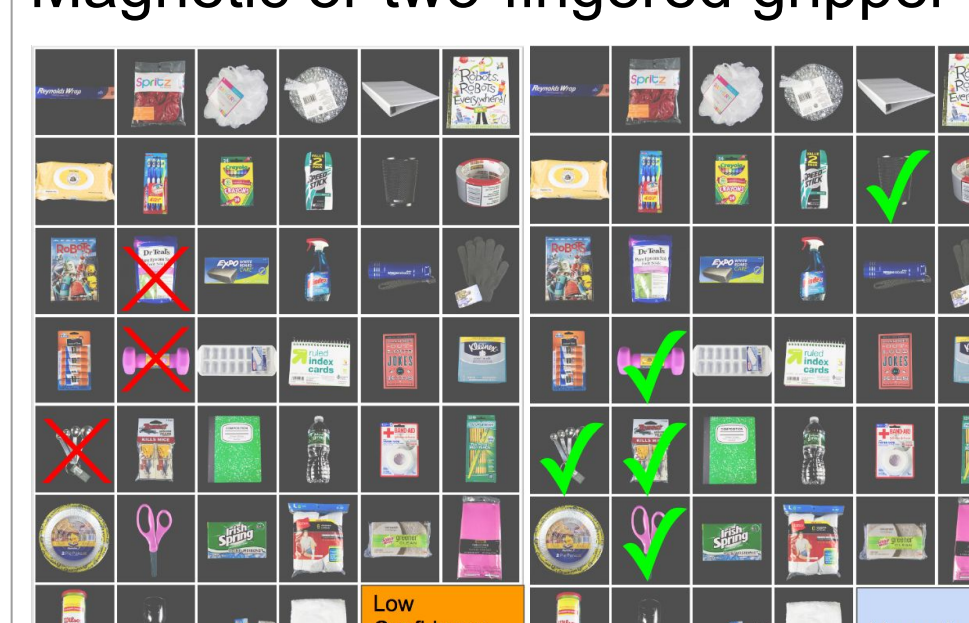
Planning: EGWA plan times were on the order of .2-.3 seconds per plan, and planning execution was around 3 seconds per plan. Path constraints reject any plans that would cause tangling of any of its hosing or wiring.

Grasping: Grasp metrics worked as expected and generated appropriate poses for each item. Motion constraints for the 1-DOF gripper need to be added to prevent shearing items at the edge of bins.



Future Work

The system needs improvements in many aspects in order to compete in the challenge. Following is a list of tasks we need to work on:

Unknown item	Higher vision accuracy and light insensitivity	Faster picking and stowage
	 Original Image  Whitening Result	
Actuated shelf	More advanced state machine	Magnetic or two-fingered gripper
		

Acknowledgement

