ECSE/CSDS 376/476
Lab 4: PCL Processing
Assigned: 4/12/21
Due: 4/19/21

This assignment is a **group** assignment. This does not require access to the robot, since we are providing PCD snapshots for you.

The objectives are:
1) to create a transform that relates the camera frame to the robot's torso frame
2) to calibrate and validate coordinates of blocks with respect to the torso frame, as seen by the camera

Part 1: Depth camera extrinsic calibration
Please review the (recorded) lecture on camera calibration using rviz.

You should create a transform publisher that relates the camera frame to the robot's torso frame.
You will know that your transform is reasonable when rviz displays pointcloud points aligned with the robot's model of the arm.

The relevant files are in arm_images.zip on Canvas under "files."

Part 2: Finding coordinates of targets
A set of 11 pcd snapshots of rectangular blocks on Table 1 are included in rectangular_blocks.zip on Canvas under "files." For each of these images, the robot's right arm was positioned such that the gripper fingers straddled the block near its center, approaching from vertical. The robot poses would be suitable for block grasp. (Actually, the fingers were touching the table surface for these poses, so the arm command should request a position slightly higher than this.)

The coordinates of the gripper poses for 4 of the blocks were obtained using tf_echo for the right-hand gripper with respect to the robot's torso frame. The poses for blocks 5, 8, 9 and 10 were:

arm5:
- Translation: [0.644, 0.015, -0.186]
- Rotation: in Quaternion [0.947, 0.321, 0.014, 0.005]
  in RPY (radian) [3.124, -0.023, 0.654]
  in RPY (degree) [178.987, -1.328, 37.464]

arm8:
- Translation: [0.800, -0.401, -0.180]
- Rotation: in Quaternion [0.714, 0.700, 0.017, 0.015]
  in RPY (radian) [3.097, -0.003, 1.551]
  in RPY (degree) [177.423, -0.183, 88.866]

arm9:
- Translation: [0.414, -0.410, -0.186]
- Rotation: in Quaternion [0.734, 0.679, 0.018, -0.006]
  in RPY (radian) [3.126, -0.035, 1.494]
  in RPY (degree) [179.125, -2.008, 85.597]

arm10:
- Translation: [0.464, 0.095, -0.186]
- Rotation: in Quaternion [0.915, 0.403, 0.017, -0.023]
    in RPY (radian) [-3.113, -0.050, 0.829]
    in RPY (degree) [-178.379, -2.872, 47.486]

The arm was then moved out of the way carefully (so as not to disturb the block nor the robot's base or camera). A PCD snapshot was then acquired. As a result, the pcd files have corresponding coordinates for the viewed blocks, as expressed in robot coordinates (and with a suitable approach pose for grasping).

You should apply pointcloud processing to identify the coordinates of the blocks in the robot's torso frame based on the 3-D images.

We will discuss code in class to help out with this. The code will be posted on Canvas.

Deliverables:

Submit a (group) report. Include screenshots showing the results of your torso/camera calibration. Include the launch file you used to get your result.

Additionally, state your computed coordinates, in the robot's torso frame, for all of the block poses. Each block frame has its origin at the table surface, centered on the lower face of the block.

Your block coordinates will be compared to the known (but not disclosed) robot-arm poses.

For manipulation, you will need to extend this to find the major axis of the block as well, and thus be able to command the orientation of the gripper appropriately. But this will be deferred for now.

Describe your process and include observations regarding your results.