Lab 6/ Project + Extra Credit Assignment

6.1 Objectives

This project will integrate your work done in previous labs with Python, ROS, OpenCV, and forward/inverse kinematics. This project will allow you to further explore the OpenCV library and implement more complex pick and place tasks.

- Use OpenCV functions to find and mark the centroids of multiple colored blocks that make up a larger object.
- Use centroids of multiple blocks to determine the orientation of the object.
- Report the world frame coordinates (x_w, y_w, ω_w) of the centroid of the object in the cameras view.
- Move each object to the designated location.

6.1.1 References

- Appendix B which explains how to derive the intrinsic and extrinsic equations for the camera.
- HSV Color Space:
  - `https://en.wikipedia.org/wiki/HSL_and_HSV`
  - `https://stackoverflow.com/questions/10948589/`
  - Converting RGB to HSV
- Simple Blob Detector:
  - `https://www.learnopencv.com/blob-detection-using-opencv-python-c/`
  - `https://stackoverflow.com/questions/8076889/`
  - `https://www.programcreek.com/python/example/89350/cv2.SimpleBlobDetector`
  - `https://www.programcreek.com/python/example/71388/cv2.SimpleBlobDetector_Params`

6.2 Task

In this lab, we will continue using built-in functions in the OpenCV library to locate blocks based on their color and find their centroids. They will allow us to efficiently complete tasks without having to develop algorithms ourselves.

Similar to Lab 5, the task for this assignment is to pick and place blocks within the robots taskspace. The TA will place the blocks at a random location within the cameras field of view. The goal is to line up each block next to one another, such that the orientations are parallel to the world frames x-axis.

To accomplish this, we will need to extract the objects pose information using the centroids from multiple blocks in the form $(x_{\text{start}}, y_{\text{start}}, \omega_{\text{start}})$. Using the inverse kinematics subroutine implemented in the previous lab, we can obtain the goal joint states. Once we have obtained the start and goal joint states, we can use the move block subroutine to move the blocks.

The intent for this assignment is to be open-ended so students can be creative with their solutions.

6.2.1 Block Construction

In this lab, we will use larger blocks comprised of 3 normal blocks to have a meaningful orientation. The steps to construct a larger block for use in your lab are simple:

1. Select three different colored blocks.
2. Place them adjacent to each other in a line.
3. Use tape around the outside edges to fasten all the blocks together to create the larger block.

This will leave you with a large block with both a meaningful orientation and three different colors visible to the camera. Finding the centroids of each colored block can aid you in determining its position and orientation in the work area.

NOTE: Please do not deconstruct any larger blocks you find already made by previous groups. Feel free to use any pre-made blocks you find if you do not wish to make your own.

6.3 Report

None required.

6.4 Demo

Show your TA the program you created. Your program should successfully pick the blocks and place them neatly aligned with the world x-axis on the left side of the work area. You will need at least 2 blocks with the same color-scheme and should place them oriented the same way (i.e., not flipped color-wise).

6.5 Grading

This project will count for 15% of the final grade. The project itself will be graded out of 75 points. The first 50 points are given according to the following scheme:

Each demo attempt will deduct 5 points from your score on this lab. If you take more than 5 attempts to successfully demo. A demo attempt is defined as showing a TA your solution when the TA places the blocks in the workspace. If the student places the blocks, it does not count as a demo attempt.

Grading Scheme

- Successful demo on first attempt: 50 credit points earned
- Second attempt: 45 points
- Third attempt: 40 points
- Fourth attempt: 35 points
- Fifth attempt: 30 points and so on.

The extra 25 points will be given based on additional work done. This can include variations on the task above, gazebo simulations (on this or a different problem you wish to solve), or a video on a topic of your choosing (robotics related, and showing sufficient use of the techniques developed in this class), as explained in class.

The delivereable for the extra part of the project is a narrated video, between 4-10 minutes in length, describing in details what you have done and learned in the project. Some examples are

- `https://www.youtube.com/watch?v=wKlYYH8nbag`
- `https://www.youtube.com/watch?v=XGPg_lJSSlM`

More can be found online.

The submission of the extra part will be via submitting in Gradescope a link to your video, as well as the name of your groups members (each member of a group needs to make a submission). You can store your video on Youtube (as listed or unlisted), on Mediaspace or on the university Box or Onedrive cloud storage.