

Milestone 2: Trajectory Generation

For this milestone, a reference trajectory generator is created for an end effector of a KUKA youBot.

The code consists of the following functions:

$$\begin{aligned} & trajectory_generator(T_{s,e_{initial}}, T_{s,c_{initial}}, T_{s,c_{final}}, T_{c,e_{grasp}}, T_{c,e_{standoff}}, k) \\ & flatten_configs(configs, gripper_state) \\ & traj_list_to_csv(traj_list) \end{aligned}$$

I. Trajectory Generator:

This function creates the sets of trajectory segments required for the pick and place operation. As input, it takes in the configurations of the end effector and cube during different points: initially, during standoff, grasping, and at the goal.

The operations can be broken down into the following steps:

1) Move the gripper from its initial position to the standoff (above the cube)
2) Move the gripper from the standoff to the grasp position (around the cube)
3) Close the gripper to grasp the cube
4) Move the gripper back up to the standoff position
5) Move the gripper to a standoff above the final position
6) Move the gripper to the final position
7) Open the gripper to release the cube
8) Move the gripper to back up to the standoff
9) Return the gripper to its original position

To calculate the configurations needed to achieve these trajectories, the modern robotics ScrewTrajectory and CartesianTrajectory functions are used. Screw trajectories couple movement involving rotation and translation while Cartesian decouple them. For these operations, a screw trajectory is used for steps 1, 2, 4, 5, 6, 8, and 9. Cartesian trajectories are used for the gripper movements, steps 3 and 7. Notably, the initial and goal configurations for gripper “trajectories” are actually the same since the end effector does not move while it opens and closes.

II. Flatten Configurations

After having generated a list of configurations for the trajectory of the gripper, they are converted to 13-vectors with 9 elements for the rotation matrix, 3 for the translation vector, and 1 for the gripper state.

III. Converting to CSV

The flattened configurations are converted to a .csv file for simulation playback in CoppeliaSim. This .csv file is generated within the main function.