**Denso 6-DOF Manipulator** **Pick and Place**

**1. Purpose**

In this assignment you will be writing a DENSO PAC code to use the Denso 6-DOF Manipulator to pick up a Plexiglas cylinder at a given location and to place it at a second location.

**2. Objectives**

1. Use the inverse differential kinematics algorithm to find the joint angles for the pick and place poses.
2. Program the DENSO controller to place the end-effector to the given poses and to open and close the pneumatic gripper.

**3. Requirements for Pick and Place Task**

Demonstrate to the laboratory faculty:

1. A working PAC script to move the manipulator from the pick pose to the place pose and to open and close the pneumatic gripper attached to the end effector to pick and place small Plexiglas cylinders.

**4. Resources for Pick and Place Task**

The position and the absolute XYZ minimal representation of the orientation of the pick pose are given by (Positions are given in mm and orientations in degrees):

|  |  |
| --- | --- |
| , |  |
| The position and the absolute XYZ minimal representation of the orientation of the place pose are given by: , |  |

**5. Procedure for Pick and Place Task**

**Part 1**: First determine the joint angles that corresponds to the pick/start pose , and a set of joint angles that corresponds to the place/goal pose using the differential inverse kinematic implemented in Part 1. To initialize your differential inverse kinematics for the start pose, you can use any vector, but your solution should be as close as possible to the following configuration vector:

|  |  |
| --- | --- |
| rad |  |

Repeat the same operation with the goal pose using as reference:

|  |  |
| --- | --- |
| rad |  |

The 6 joint angles in Equation above are given in radians. **Define also one waypoint close to the place pose but with a smaller y value (outside the hole) that the end-effector reaches first before moving inside the hole (place pose).**

Afterwards, write a PAC script to:

1. Approach the pick pose using point-to-point interpolation, speed 40%, and distance .
2. Move to the pick pose using linear interpolation and speed 10%.
3. Close the pneumatic gripper.
4. Depart from the pick pose using linear interpolation, speed 20%, and distance 40 mm.
5. Move to the waypoint close to the place pose using point-to-point interpolation and speed 40%.
6. Move to the place pose using linear interpolation and speed 10%.
7. Open the pneumatic gripper.
8. Depart from the pick pose using linear interpolation, speed 20%, and distance 40 mm.
9. Approach the pick pose using point-to-point interpolation, speed 40%, and distance .

To store joint variables in your PAC script use the following commands (**angles in the PAC script are given in degrees!**):

DIM VariableName As Joint

VariableName = (22, 33, 44, -33, -22, -11)

To close the pneumatic gripper use the following sequence of commands:

DELAY 500

SET IO[28]

DELAY 500

To open the pneumatic gripper use the following sequence of commands:

DELAY 500

RESET IO[28]

DELAY 500

Save your PAC script in a file named using your first name and the \*.pac extension, and drop your file in the network folder.

Solution angles in degrees are:

degrees

degress

Table 1: Manipulator figures.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **6-th Axis Figure** | **Wrist Figure** | **Elbow Figure** | **Shoulder Figure** |
| 0 | SINGLE | FLIP | ABOVE | RIGHTY |
| 1 | SINGLE | FLIP | ABOVE | LEFTY |
| 2 | SINGLE | FLIP | BELOW | RIGHTY |
| 3 | SINGLE | FLIP | BELOW | LEFTY |
| 4 | SINGLE | NONFLIP | ABOVE | RIGHTY |
| **5** | **SINGLE** | **NONFLIP** | **ABOVE** | **LEFTY** |
| 6 | SINGLE | NONFLIP | BELOW | RIGHTY |
| 7 | SINGLE | NONFLIP | BELOW | LEFTY |
| 8 | DOUBLE | FLIP | ABOVE | RIGHTY |
| 9 | DOUBLE | FLIP | ABOVE | LEFTY |
| 10 | DOUBLE | FLIP | BELOW | RIGHTY |
| 11 | DOUBLE | FLIP | BELOW | LEFTY |
| 12 | DOUBLE | NONFLIP | ABOVE | RIGHTY |
| 13 | DOUBLE | NONFLIP | ABOVE | LEFTY |
| 14 | DOUBLE | NONFLIP | BELOW | RIGHTY |
| 15 | DOUBLE | NONFLIP | BELOW | LEFTY |

**6. Deliverables:**

In a zipped folder named with your first and last name and the lab number, include the following items and submit on canvas under assignments/lab report 5.

1. Lab report in pdf.
2. Working PAC codes that performs the tasks illustrated in the Procedure Section.