PROJECT REPORT

The 7-degree-of-freedom robot (LBR iiwa 7R800, KUKA) is coded to be moved from its initial configuration "qi" to final configuration which is placing a flange mounted on the end effector on the specified location.

Formulas and calculations and Procedure

computed Transformation matrix from base to end-effector using the DH-Table.

$$\text{Transformation matrix} = \begin{bmatrix} \cos\theta_i & -\sin\theta_i\cos\alpha_i & \sin\theta_i\sin\alpha_i & a_i\cos\theta_i \\ \sin\theta_i & \cos\theta_i\cos\alpha_i & -\cos\theta_i\sin\alpha_i & a_i\sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Transformation matrices for each joints are computed and multiplied to get transformation from Base to end effector.

$$T0E = T01 \times T12 \times T23 \times T34 \times T45 \times T56 \times T6E$$

$$T0E = \begin{bmatrix} 0.6743 & 0.6386 & 0.3707 & -0.2390 \\ 0.5323 & -0.7683 & 0.3554 & 0.5086 \\ 0.5118 & -0.0423 & -0.8581 & 0.3016 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Now computed transformation matrix from End effector to camera frame where $d = 0.0431$; $\theta = -90^{\circ}$; $a = 0.0662$, $\alpha = 0$.

$$TEC = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & -0.0662 \\ 0 & 0 & 1 & 0.0431 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

~~Trans~~ we are Given Roll, pitch, yaw and X, Y, Z coordinates for transformation matrix of camera to Aruko marker which can be done with the

Function eul2rotm([eulerangles], 'rotationsequence')

$$TCA = \begin{bmatrix} 0.3211 & 0.9455 & 0.0541 & -0.1420 \\ 0.8238 & -0.3070 & 0.4765 & -0.0606 \\ 0.4671 & -0.1084 & -0.8475 & 0.3528 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

then transformation matrix from Arokomarker to target is computed — TAT

when multiplied all these we get final transformation from base to Target

$$TOT_8 = TOE \times TEC \times TCA \times TAT$$

$$= \begin{bmatrix} 0.5236 & -0.8511 & -0.0386 & 0.0582 \\ 0.8512 & 0.5245 & -0.0166 & 0.5928 \\ 0.0344 & -0.0242 & 0.9991 & -0.0662 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

then found a transformation matrix from End effector to object and multiplied with $\overline{T}_R$.

$$T\_TObj^{o} = \begin{bmatrix} 0.8511 & -0.5236 & 0.0386 & 0.0797 \\ -0.5245 & -0.8512 & 0.0166 & 0.6305 \\ 0.0242 & -0.0344 & -0.9991 & -0.0047 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

then inverse kinematics computed from the initial robot configuration with a gain of 20 and a total of 10,00,000 steps and a $\Delta t = 0.01$ is taken to find the final Robot configuration.

the angles are converted into their respective equivalent angles so that the joints may not over-rotate and Reach joint limits.

the final configuration is.

$$q = \begin{bmatrix} -103.0438 & -76.4793 & 10.8458 & 66.3461 & 159.2880 & 37.8771 & -52.5154 \end{bmatrix}$$

After reaching the final configuration, trajectory planing was done for the robot.

A cubic polynomial equation was considered. Since only the initial and final velocity was set to be zero.

$$\therefore q(t) = a_3 t^3 + a_2 t^2 + a_1 t + a_0$$

$$q(0) = q_i$$

$$q(t_f) = q_f$$

$$\dot{q}(t) = 3a_3 t^2 + 2a_2 t + a_1$$

$$\dot{q}(0) = 0$$

$$\dot{q}(t_f) = 0 \Rightarrow a_0 = q_1$$

$$a_1 = 0$$

$$a_2 = \frac{-3 \times (q_1 - q_f)}{t^2}$$

$$a_3 = \frac{2 \times (q_1 - q_f)}{t_f^3}$$

Trajectories and velocities of each joint for every 5milliSeconds for 10seconds was calculated using for Loop. and produced in a text files joint velocities are checked used function.