Dynamic of Nonlinear Robotic Systems First Assignment

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Figure 1: Mitsubishi robot RV-1A

Abstract

This report is part of Dynamics of Non Linear Robotic Systems [DNLRS] course for first year master students at Innopolis University. In this report I am working on Mitsubishi robot RV-1A. I solved both forward and inverse kinematics problems using Matlab R2021a. This report is stating the methods that I used while the code is available on GitHub.

1 Kinematic scheme

We can see the kinematic scheme of Mitsubishi robot RV-1A (Figure 1)

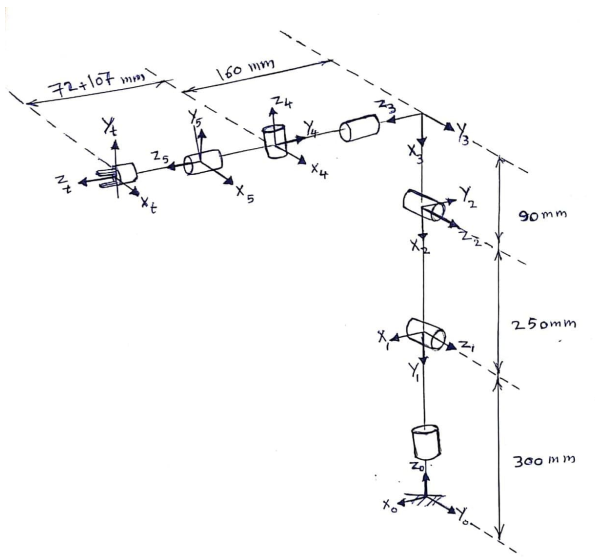

Figure 2: Mitsubishi robot RV-1A scheme.

2 Forward Kinematics

In order to solve the forward kinematics problem I will use Denavit Hartenberg, so first of all I need to find DH-parameters.

i	θ	d	α	a
0-1	θ_1	0.3	$\frac{-\pi}{2}$	0
1-2	θ_2	0	0	-0.25
2-3	θ_3	0	$\frac{\pi}{2}$	-0.09
3-4	θ_4	0.16	$\frac{-\pi}{2}$	0
4-5	θ_5	0	$\frac{\pi}{2}$	0
5-6	θ_6	0.179	0	0

Table 1: DH- Parameters

Then for each joint of the robot, populate anew T matrix with the following values:

$$T_i^{i-1} = \begin{bmatrix} cos(\theta_i) & -sin(\theta_i) \cdot cos(\alpha_i) & sin(\theta_i) \cdot sin(\alpha_i) & r \cdot cos(theta_i) \\ sin(\theta_i) & cos(\theta_i) \cdot cos(\alpha_i) & -cos(\theta_i) \cdot sin(\alpha_i) & r \cdot sin(theta_i) \\ 0 & sin(\alpha_i) & cos(\alpha_i) & d \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Then we multiply all of the matrices together starting with the first joint all the way up to the end effector. The final T matrix will contain the position and the orientation of the end effector.

$$T_6^0 = T_1^0 \cdot T_2^1 \cdot T_3^2 \cdot T_4^3 \cdot T_5^4 \cdot T_6^5$$

3 Inverse Kinematics

As we know that $q = f^{-1}(x)$, where $X = [P_x, P_y, P_z, \varphi, \theta, \Psi]$ and $q = [q_1, q_2, ..., q_n]$ and we can express the final Transformation (from the first joint to the end effector) as following:

$$T_n^0 = \begin{bmatrix} s_x & n_x & a_x & p_x \\ s_y & n_y & a_y & p_y \\ s_z & n_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{1}$$

according to the inverse Kinematic model:

$$T_6^0 = T_1^0(q_1)T_2^1(q_2)....T_6^5 \tag{2}$$

$$T_1^0(q_1)T_6^0 = T_2^1(q_2)....T_5^4T_6^5 \tag{3}$$

$$T_6^1(q_1) = T_6^1(q_2...q_6) -> q_1 \tag{4}$$

when three revolute joints whose axes intersect at a point (as it happens in joints 4, 5, 6) there wont be a change in direction of the end effector while the position will be the same, so:

$$P_6^0 = P_5^0 = P_4^0 \tag{5}$$

and:

$$\begin{bmatrix} P_{x4} \\ P_{y4} \\ P_{z4} \\ 1 \end{bmatrix} = T_1^0(q_1)T_2^1(q_2)T_3^2(q_3)T_4^3(q_4) \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \tag{6}$$

4 Results

All the code is available on GitHub.