EE209AS Lab 1
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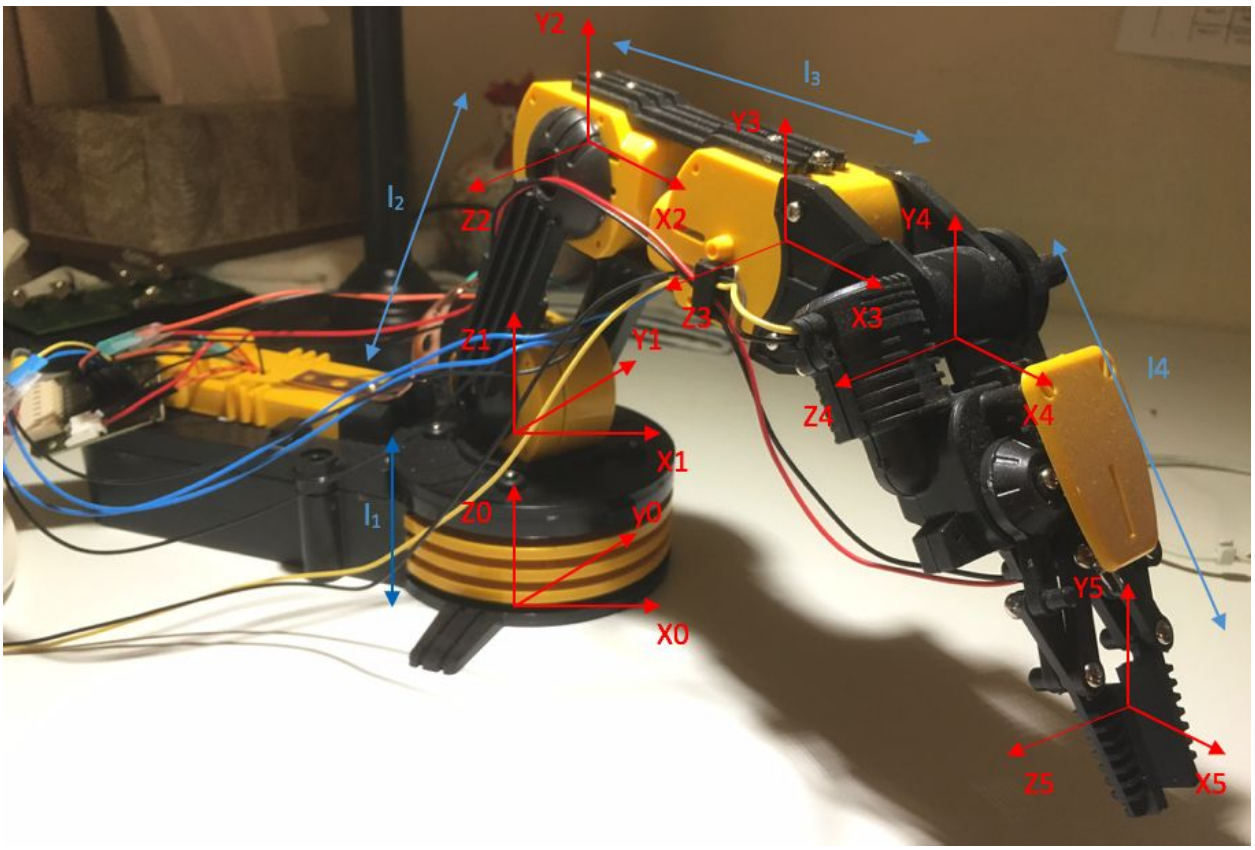
1. Introduction

Robotic arm is a great resource of hobbyist and a robotic researcher. I have a toy robotic arm (OWI Robotic Arm Edge) for research purpose. It has 4 DOF and the end effector is a claw that can grab a small object. This robotic arm has 4 rotation joints: the base can rotate 180 degree, and other joints can rotate 120 Degree. One sample task is picking up an object and placing it at user's desired location.



2. Methods

D-H parameters are provided in the following table. The parameters and axes are labeled in the picture above.

i	a_{i-1}	α_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	$\pi/2$	0	l_1	θ_2
3	0	l_2	0	θ_3

4	0	l_3	0	θ_4
5	0	l_4	0	0

Approximate link lengths are l_1 = 6 cm, l_2 = 12 cm, l_3 = 12 cm, l_4 = 12 cm, l_5 = 12 cm.

Forward kinematics are implemented using MATLAB. The script is on https://github.com/shunyaorad/EE209AS.git

To solve inverse kinematics, Jacobian matrix is obtained. Joint angles are obtained by taking pseudo inverse of the Jacobian matrix and iteratively updating joint angles until error between the desired and generated angles become smaller than threshold. The algorithm is presented below

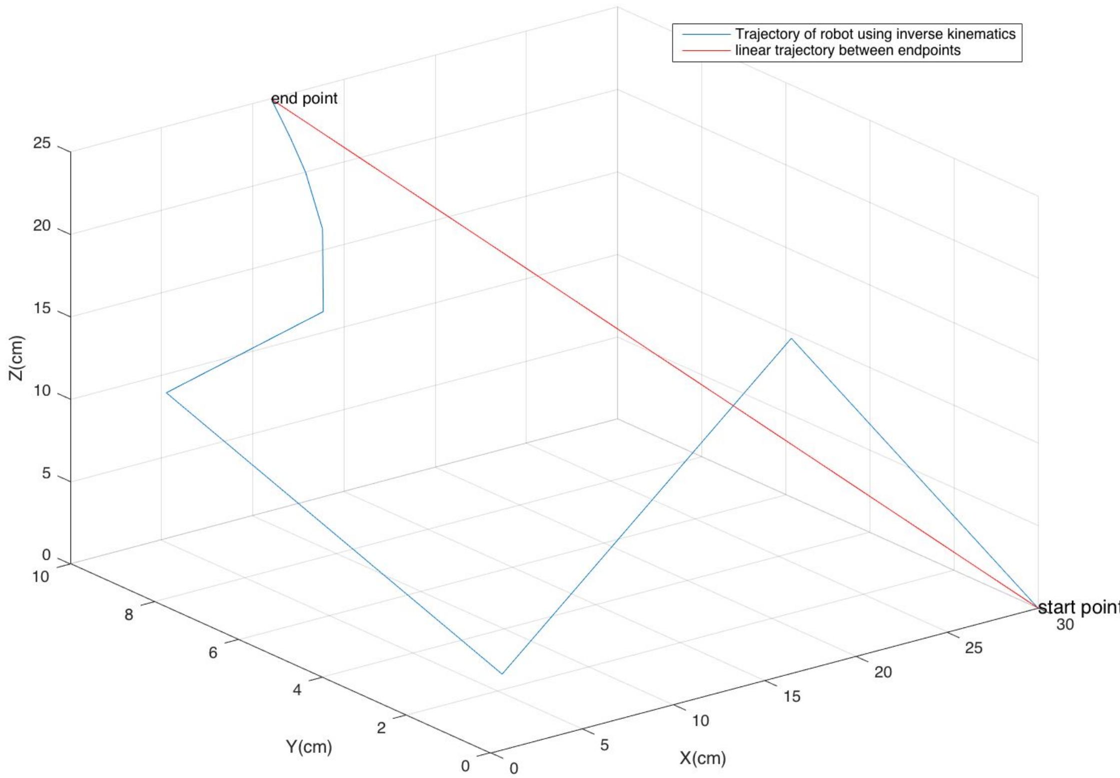
$$
\begin{aligned}
&\mathit{while}\ (\mathit{norm}(\mathit{error}) > 0.1)\\
&\qquad f(q_0) = x_0\\
&\qquad \delta x = x_{desired} - x_0\\
&\qquad \delta q = J^{-1}\delta x\\
&\qquad q_0 = q_0 + \delta q\\
&\qquad \mathit{error} = x_{desired} - f(q_0)
\end{aligned}
$$

3. Results

A. Evaluation of the robot arm motion from its initial position to target location

From experimental results, it can be concluded that the inverse kinematics is solved reasonably, making small error between the the desired position and generated position using angles obtained by inverse kinematics.

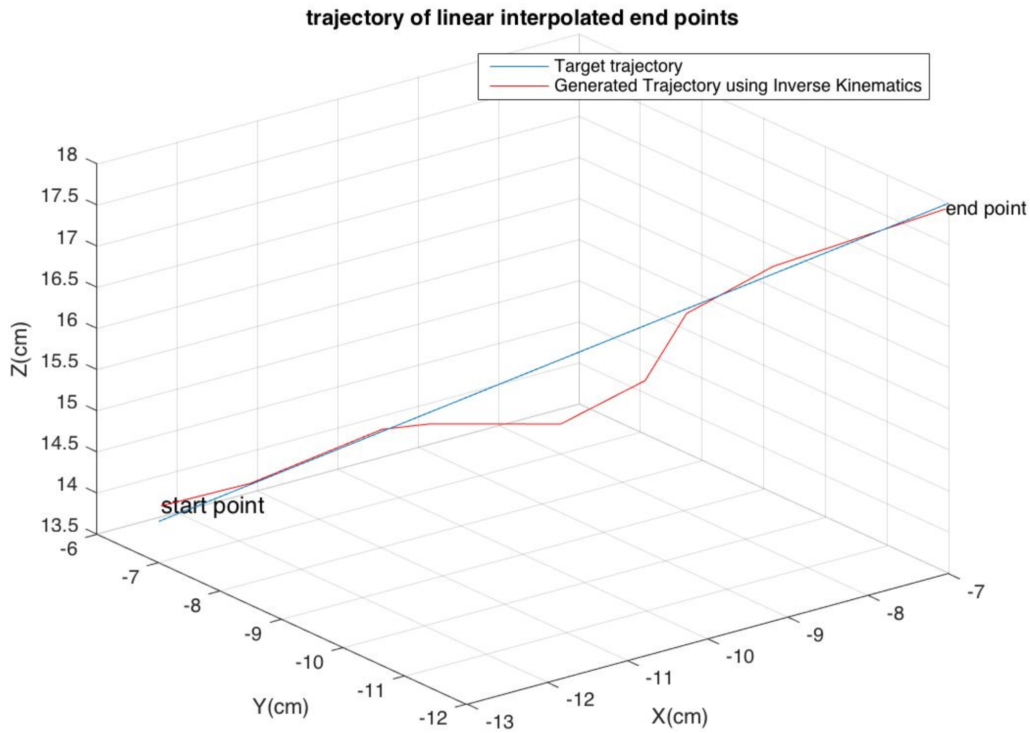
An experiment is conducted to see how the robot moves its arm from initial position to the target position. The resulting trajectory from inverse kinematics is given below.



As it can be seen, the robotic arm trajectory takes longer path than the straight line connecting the endpoints. This is inefficient trajectory and not desirable because it might interfere with other objects on the way to reach its target position. Inverse kinematics does not promise efficient trajectory to reach target location, therefore further research needs to be conducted to find better way to plan its trajectory.

B. Evaluation of accuracy of tracing desired trajectory:

Another experiment is conducted by generating linear interpolation between two end points and use that as desired trajectory for inverse kinematics. The result is presented on the figure below.



I believe this is a good result of achieving the task of carrying an object from one point to another as the error of the trajectory and desired trajectory is small.

Final Thoughts on the lab:

I definitely enjoyed the lab as it is useful for my own project of understanding inverse kinematics. However, I spent a lot of time (10+ hours) on researching and figuring out how to solve inverse kinematics. I wish there was an example of solving inverse kinematics in lecture using actual system so that I'm more confident about the process. I think this lab could be easier if there were more examples in the lecture.