(Name or UUN) focused on part 2 (Vision) of the coursework and (Name or UUN) focused on part 3 (Control) of the coursework. We both helped each other in our respective parts. Part 4 was worked on by both members.

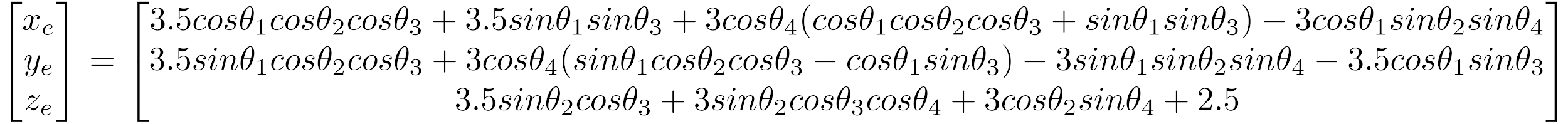
Github link: <https://github.com/Ziemniok352/IVR-Assignment/>

**Part 2**

(Add plots and answers here)

**Forward Kinematics 3.1**

The result of my forward kinematic calculation:

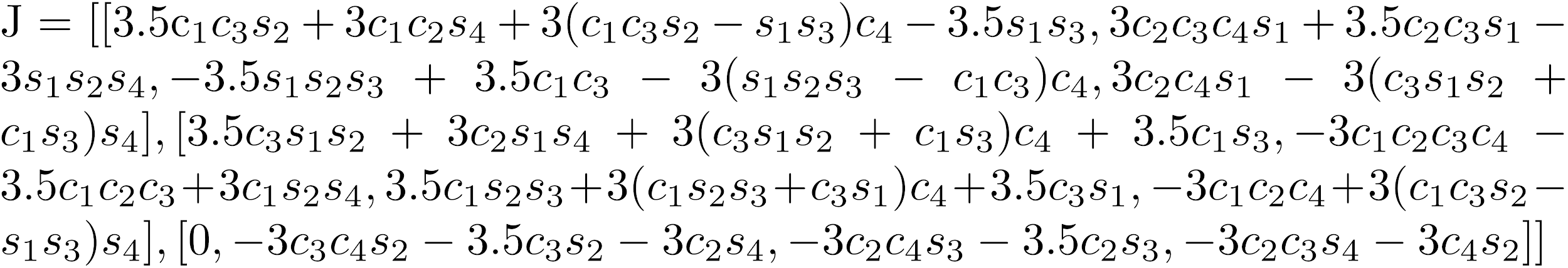
[****](#D2L_code_render_\begin{bmatrix}x_e\\y_e\\z_e\end{bmatrix} = \begin{bmatrix}3.5cos\theta_1cos\theta_2cos\theta_3 + 3.5sin\theta_1sin\theta_3 + 3cos\theta_4(cos\theta_1cos\theta_2cos\theta_3 + sin\theta_1sin\theta_3) - 3cos\theta_1sin\theta_2sin\theta_4\\3.5sin\theta_1cos\theta_2cos\theta_3 + 3cos\theta_4(sin\theta_1cos\theta_2cos\theta_3 - cos\theta_1sin\theta_3) - 3sin\theta_1sin\theta_2sin\theta_4 - 3.5cos\theta_1sin\theta_3\\3.5sin\theta_2cos\theta_3 + 3sin\theta_2cos\theta_3cos\theta_4 + 3cos\theta_2sin\theta_4 + 2.5\end{bmatrix})

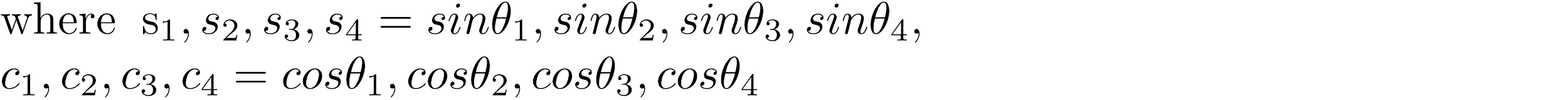
|  |  |  |
| --- | --- | --- |
| **Joint angles ()** | **Est. end-effector from image (**x,y,z**)** | **Est. end-effector from Forward Kinematics (**x,y,z**)** |
| (0.1,0.1,0.1,0.1) | **X: -15.674, Y: -15.932, Z: 11.548** | **x: 0.738, y: -0.873, z: 8.890** |
| (0.5,-0.5,0.5,-0.5) | **X: -16.182, Y: -21.883, Z: 14.575** | **x: 0.738, y: 4.782, z: 6.534** |
| (2.7, 0.3, 1.3, 0.9) | **X: 3.073, Y: -20.656, Z: 18.133** | **x: -3.533, y: 4.622, z: 3.177** |
| (1, -0.8, 1.2, 1.4) | **X: 18.986, Y: 19.598, Z: -15.594** | **x: 2.875, y: 2.595, z: 5.633** |
| (pi, pi/2, pi/2, pi/2) | **X: 12.926, Y: 15.830, Z: -23.747** | **x: -3.500, y: 0.000, z: -0.500** |
| (-pi, pi/2, -pi/2, pi/2) | **X: 20.431, Y: 19.149, Z: -24.309** | **x: 3.500, y: 0.000, z: -0.500** |
| (-1.6, 0.4, 1.1, -1.4 ) | **X: 17.304, Y: 21.344, Z: -16.169** | **x: 1.909, y: -3.631, z: 5.327** |
| (0.25, -0.35, 0.8, -1.1) | **X: 10.544, Y: 14.366, Z: -16.286** | **x: 2.470, y: 4.421, z: 4.764** |
| (-0.3, 1.5, 0.2, 1.5) | **X: 20.448, Y: 22.562, Z: -24.966** | **x: -0.430, y: -3.887, z: -0.228** |
| (-2.15, -0.6, -1.5, - 0.3) | **X: 24.179, Y: 11.752, Z: -20.022** | **x: 4.301, y: 4.775, z: 2.371** |

Comment on accuracy here

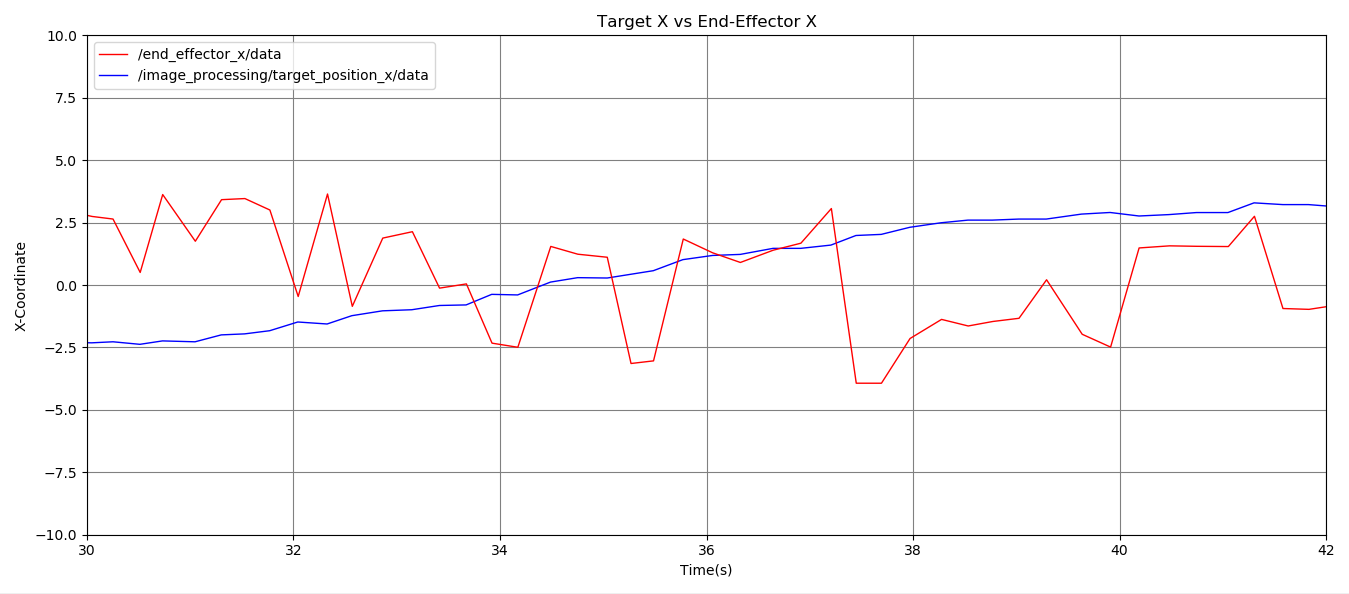
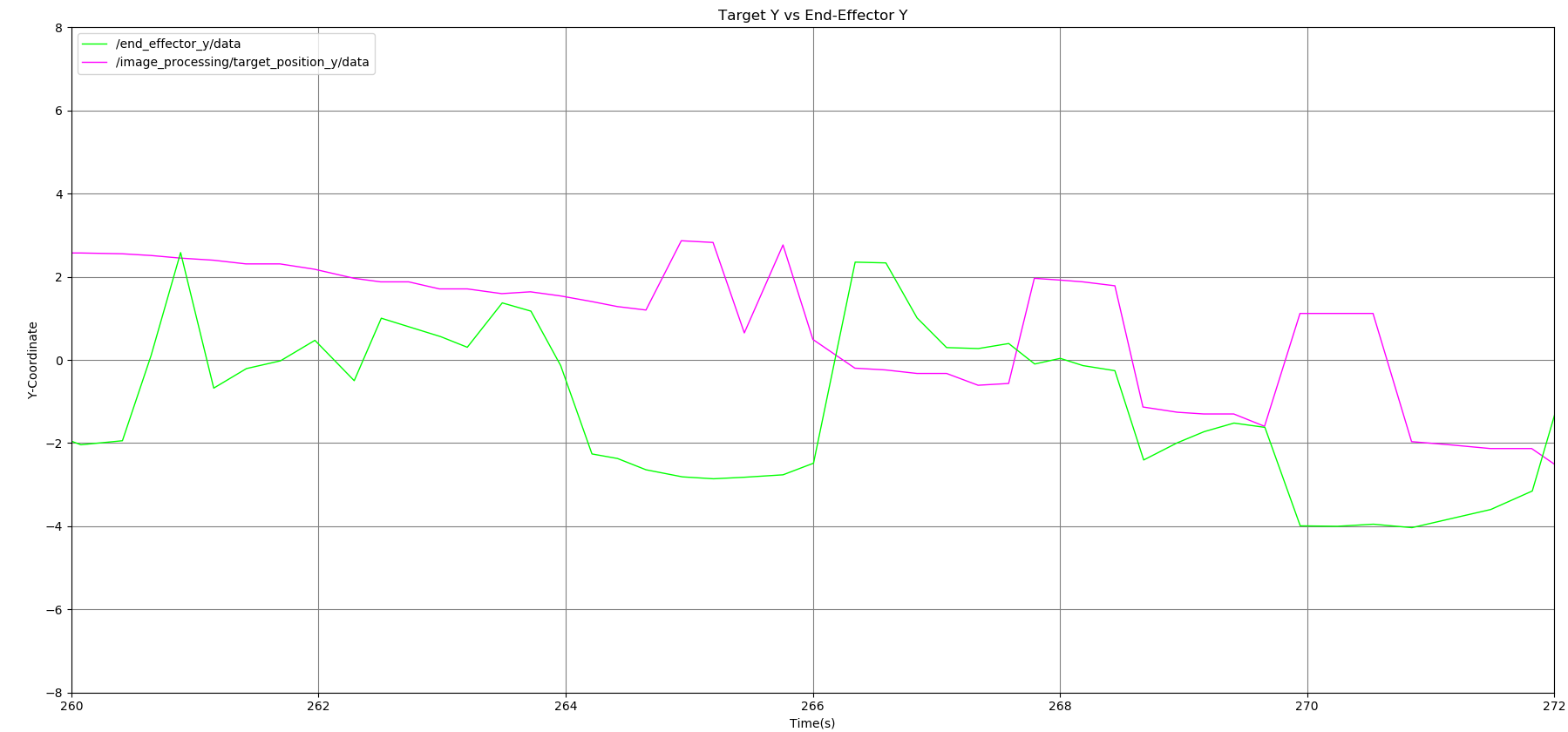
**Closed-loop Control 3.2**

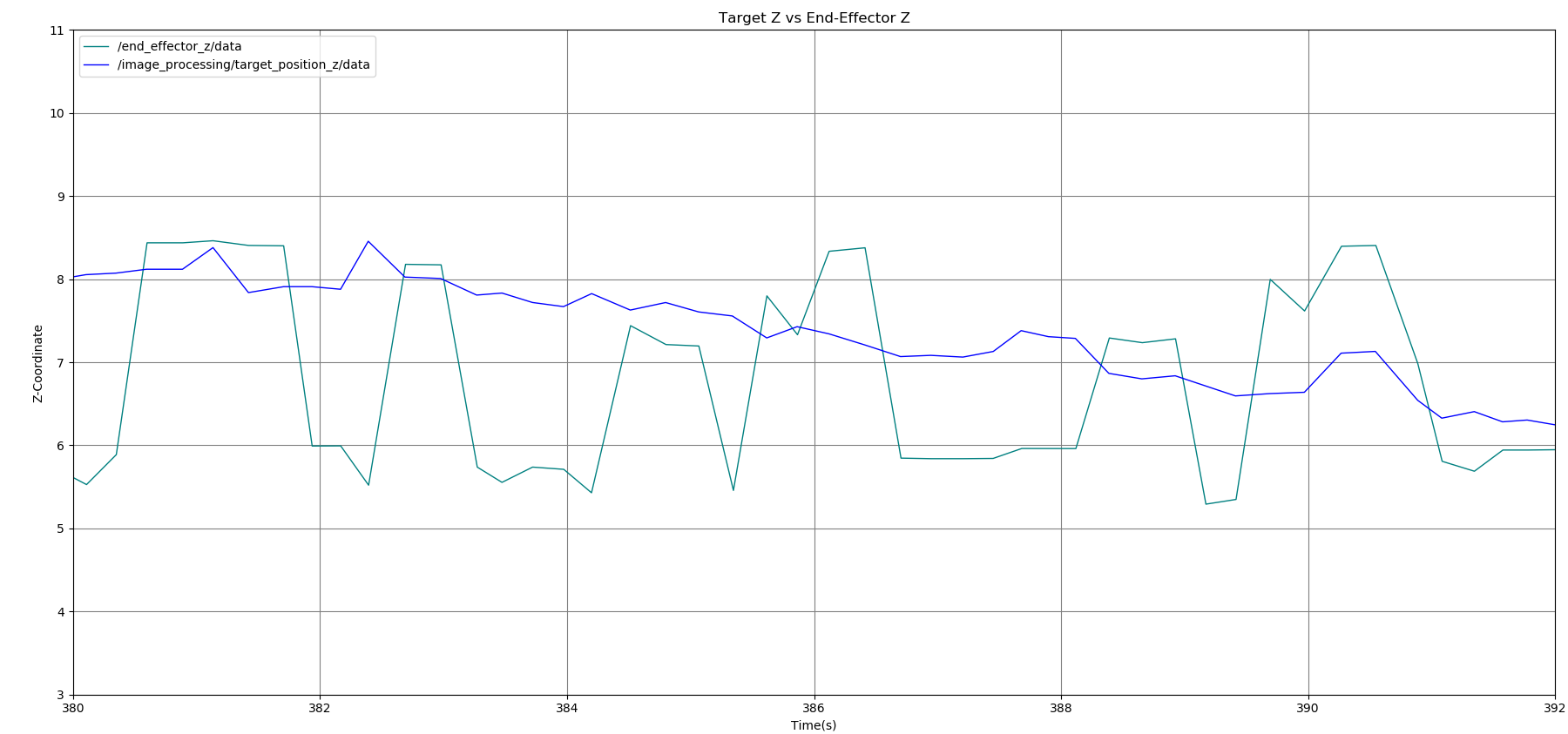
The result of my jacobian calculation:

[](#D2L_code_render_J = [[3.5c_1c_3s_2 + 3c_1c_2s_4 + 3(c_1c_3s_2 - s_1s_3)c_4 - 3.5s_1s_3, 
3c_2c_3c_4s_1 + 3.5c_2c_3s_1 - 3s_1s_2s_4, -3.5s_1s_2s_3 + 3.5c_1c_3 - 3(s_1s_2s_3 -                c_1c_3)c_4, 3c_2c_4s_1 - 3(c_3s_1s_2 + c_1s_3)s_4],
                [3.5c_3s_1s_2 + 3c_2s_1s_4 + 3(c_3s_1s_2 + c_1s_3)c_4 + 3.5c_1s_3,
                -3c_1c_2c_3c_4 - 3.5c_1c_2c_3 + 3c_1s_2s_4, 
                3.5c_1s_2s_3 + 3(c_1s_2s_3 + c_3s_1)c_4 + 3.5c_3s_1, -3c_1c_2c_4 + 3(c_1c_3s_2 - s_1s_3)s_4],
                [0, -3c_3c_4s_2 - 3.5c_3s_2 - 3c_2s_4, -3c_2c_4s_3 - 3.5c_2s_3, -3c_2c_3s_4 - 3c_4s_2]])

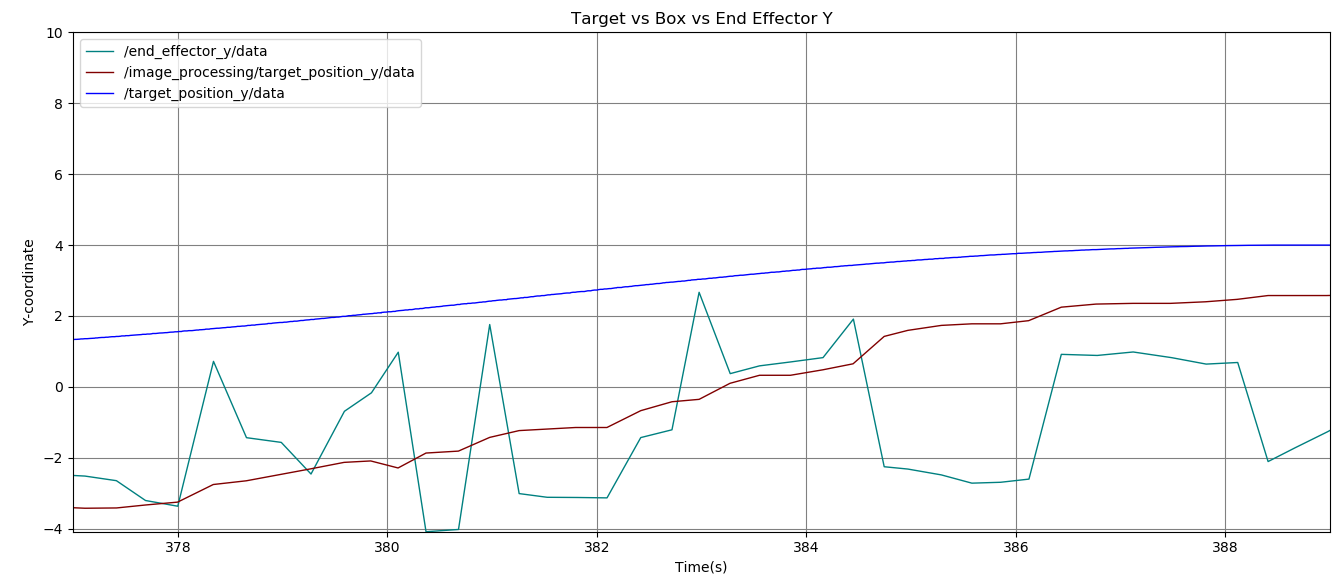
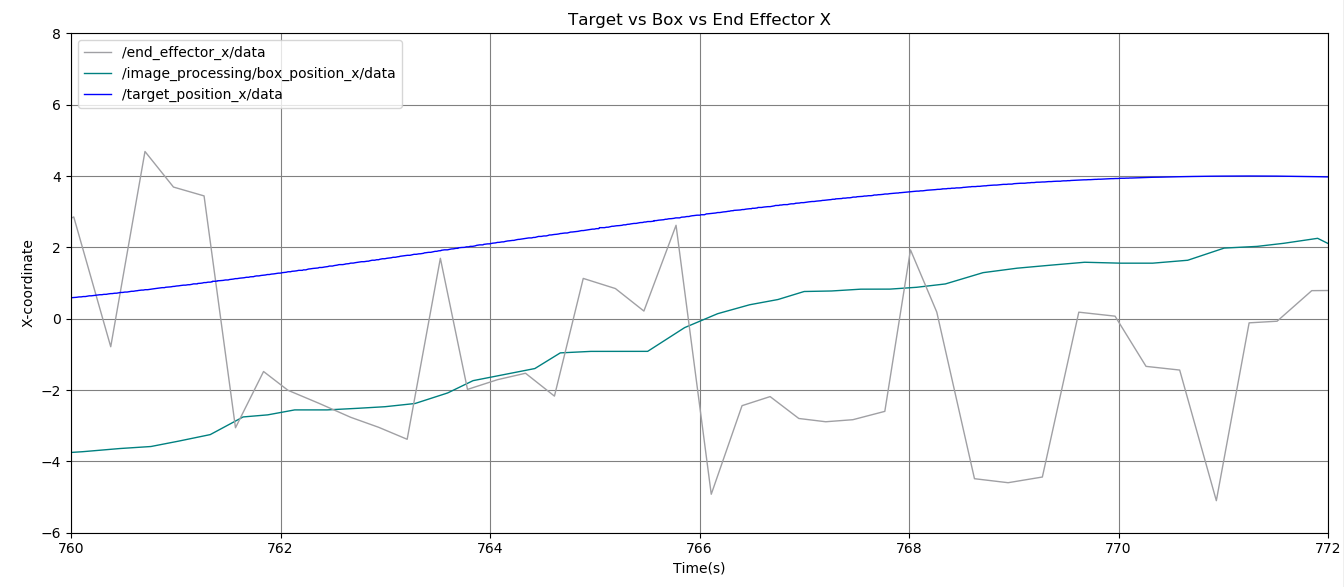
[](#D2L_code_render_where\: s_1,s_2,s_3,s_4 = sin\theta_1, sin\theta_2, sin\theta_3, sin\theta_4,\\c_1,c_2,c_3,c_4 = cos\theta_1, cos\theta_2, cos\theta_3, cos\theta_4)

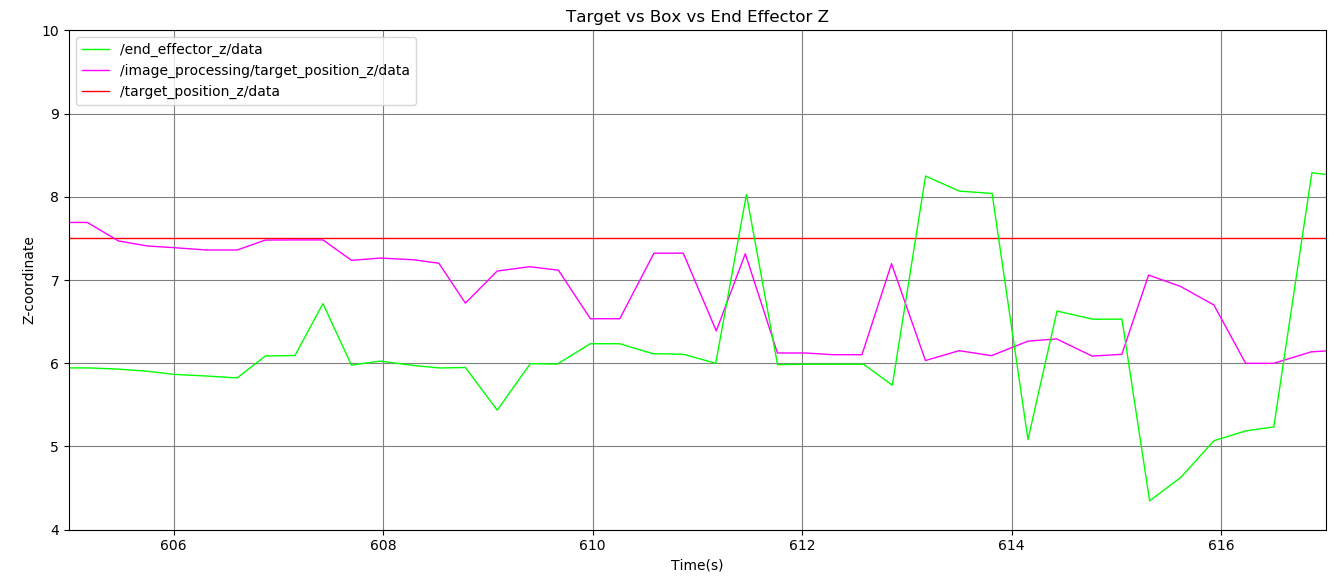
Plot 3 graphs comparing x,y,z pos of end effector with x,y,z of target





**4.2**

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