IVR Coursework

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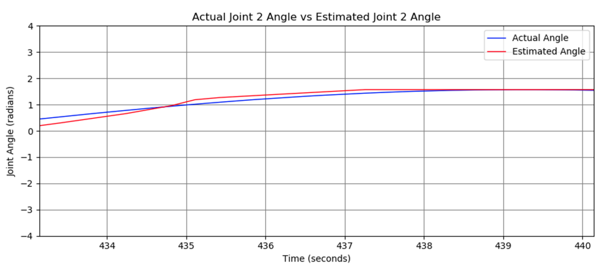
Neil and Matt worked on this coursework collaboratively - answering all questions and coding together. Thus there was an equal contribution from both members of the team.

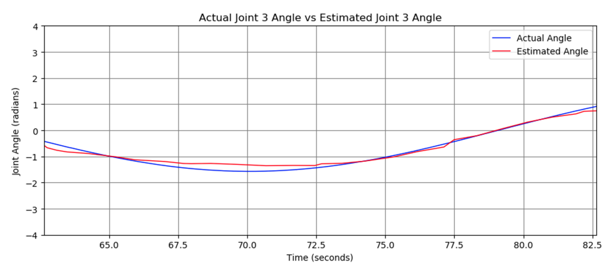
Access the GitHub link to our code here: `https://github.com/the-raspberry-pi-guy/IVR-Assignment`

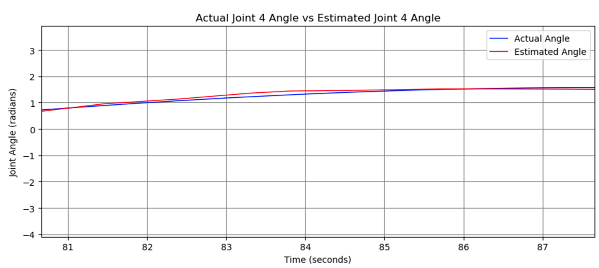
2 Robot Vision

2.1 Joint State Estimation

DESCRIBE ALGORITHM

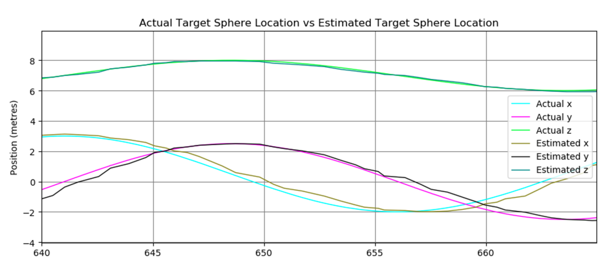






2.2 Target Detection

DESCRIBE ALGORITHM & COMMENT ON SOURCES OF ERROR IN MEASUREMENTS



3 Robot Control

3.1 Forward Kinematics

$$\begin{bmatrix} 3s(\theta_1)s(\theta_2)c(\theta_3)c(\theta_4) + 3.5s(\theta_1)s(\theta_2)c(\theta_3) + 3s(\theta_1)s(\theta_4)c(\theta_2) + 3s(\theta_3)c(\theta_1)c(\theta_4) + 3.5s(\theta_3)c(\theta_1) \\ 3s(\theta_1)s(\theta_3)c(\theta_4) + 3.5s(\theta_1)s(\theta_3) - 3s(\theta_2)c(\theta_1)c(\theta_3)c(\theta_4) - 3.5s(\theta_2)c(\theta_1)c(\theta_3) - 3s(\theta_4)c(\theta_1)c(\theta_2) \\ -3s(\theta_2)s(\theta_4) + 3c(\theta_2)c(\theta_3)c(\theta_4) + 3.5c(\theta_2)c(\theta_3) + 2.5 \end{bmatrix}$$

Joint Angle *Joint 1,2,3,4 (rad)*	Estimated via FK *x,y,z (m)*	Estimated via Images *x,y,z (m)*
1,0.5,0.1,-1	0.47,0.31,8.18	0.33,0.33,8.76
-1,-1,-1,1	-1.52,4.15,6.12	-1.36,3.68,6.59
0.25,0.25,0.25,0.25	2.09, -1.79, 8.33	2.24,-2.06,9.16
1,1,0.5,0.5	6.05,-0.39,4.20	6.11,-0.59,4.64
-1,-0.5,-0.1,1	4.20,2.09,5.76	3.68,2.72,6.22
1,1,1,-1	3.14,3.10,6.12	2.54,3.72,6.77
-0.25,-0.25,-0.25,-0.25	-0.98,2.58,8.33	-0.92,2.43,8.65
-1,-1,-0.5,-0.5	2.88,5.34,4.20	2.13,6.33,4.97
π, $\pi/2$, $\pi/4$, -0.1	-4.58,4.59,2.80	-3.72,3.64,3.86
$-\pi$, $-\pi/2$, $-\pi/4$, 0.1	4.59,-4.58,2.80	6.07,-6.15,2.43

COMMENT ON ACCURACY

3.2 Closed-Loop Control

$$A =$$

$$\begin{bmatrix} -3s(\theta_1)s(\theta_3)c(\theta_4) - 3.5s(\theta_1)s(\theta_3) + 3s(\theta_2)c(\theta_1)c(\theta_3)c(\theta_4) + 3.5s(\theta_2)c(\theta_1)c(\theta_3) + 3s(\theta_4)c(\theta_1)c(\theta_2) \\ 3s(\theta_1)s(\theta_2)c(\theta_3)c(\theta_4) + 3.5s(\theta_1)s(\theta_2)c(\theta_3) + 3s(\theta_1)s(\theta_4)c(\theta_2) + 3s(\theta_3)c(\theta_1)c(\theta_4) + 3.5s(\theta_3)c(\theta_1) \\ 0 \end{bmatrix}$$

$$B =$$

$$\begin{bmatrix} -3s(\theta_1)s(\theta_2)s(\theta_4) + 3s(\theta_1)c(\theta_2)c(\theta_3)c(\theta_4) + 3.5s(\theta_1)c(\theta_2)c(\theta_3) \\ 3s(\theta_2)s(\theta_4)c(\theta_1) - 3c(\theta_1)c(\theta_2)c(\theta_3)c(\theta_4) - 3.5c(\theta_1)c(\theta_2)c(\theta_3) \\ -3s(\theta_2)c(\theta_3)c(\theta_4) - 3.5s(\theta_2)c(\theta_3) - 3s(\theta_4)c(\theta_2) \end{bmatrix}$$

$$C =$$

$$\begin{bmatrix} -3s(\theta_1)s(\theta_2)s(\theta_3)c(\theta_4) - 3.5s(\theta_1)s(\theta_2)s(\theta_3) + 3c(\theta_1)c(\theta_3)c(\theta_4) + 3.5c(\theta_1)c(\theta_3) \\ 3s(\theta_1)c(\theta_3)c(\theta_4) + 3.5s(\theta_1)c(\theta_3) + 3s(\theta_2)s(\theta_3)c(\theta_1)c(\theta_4) + 3.5s(\theta_2)s(\theta_3)c(\theta_1) \\ -3s(\theta_3)c(\theta_2)c(\theta_4) - 3.5s(\theta_3)c(\theta_2) \end{bmatrix}$$

$$D =$$

$$\begin{bmatrix} -3s(\theta_1)s(\theta_2)s(\theta_4)c(\theta_3) + 3s(\theta_1)c(\theta_2)c(\theta_4) - 3s(\theta_3)s(\theta_4)c(\theta_1) \\ -3s(\theta_1)s(\theta_3)s(\theta_4) + 3s(\theta_2)s(\theta_4)c(\theta_1)c(\theta_3) - 3c(\theta_1)c(\theta_2)c(\theta_4) \\ -3s(\theta_2)c(\theta_4) - 3s(\theta_4)c(\theta_2)c(\theta_3) \end{bmatrix}$$

Where A, B, C and D are column vectors that form the Jacobian when arranged like (formatted to save space):

$$\begin{bmatrix} A & B & C & D \end{bmatrix}$$

PRESENT THREE PLOTS COMPARING THE X,Y,Z POSITION OF THE ROBOT END-EFFECTOR WITH THE X,Y,Z POSITION OF THE TARGET FOR 10 SECONDS.

4 Final Task

4.2 Null-space Control

DISCUSS ALGORITHM AND HOW IT IS DIFFERENT FROM PREVIOUS CONTROLLER. THREE PLOTS COMPARING THE POSITION OF THE ROBOT END-EFFECTOR WITH THE POSITION OF THE SPHERE AND THE POSITION OF THE BOX.