RBE501 HW2

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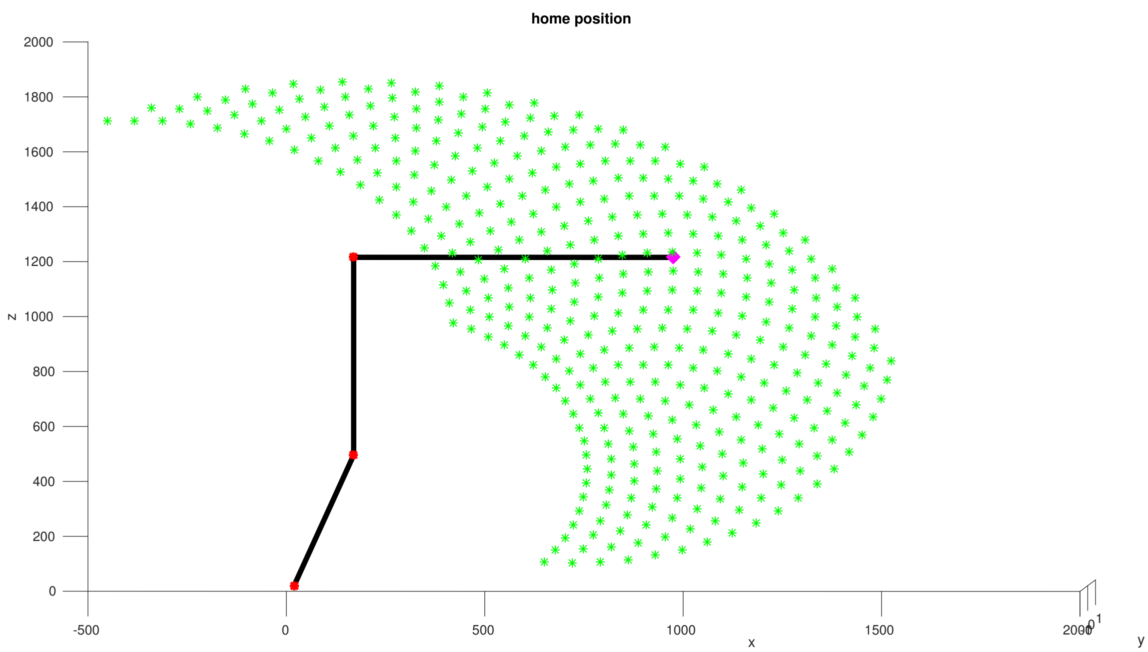
Part A

$$
\begin{aligned}
&x = 150 + 720 * cos(\theta_2) + 805 * cos(\theta_2 + \theta_3)\\
&z = 475 + 720 * sin(\theta_2) + 805 * sin(\theta_2 + \theta_3)\\
&y = 0;\\
&\quad where, -50 < \theta_2 < 50, -45 < \theta_3 < 45,
\end{aligned} \tag{1}
$$



Part B

$$
\begin{aligned}
&\theta_1 = atan2(Py, Px)\\
&\theta_2 = atan2(Pz, Px) - atan2(805 * sin(\theta_3), (720 + 805 * cos(\theta_3)))\\
&\theta_3 = acos\left[\frac{(Px^2 + Pz^2 - (720)^2 - (805)^2)}{(2(720)(805)))}\right]\\
&\theta_4 = \theta_5 = \theta_6 = \infty
\end{aligned} \tag{2}
$$

Part C

$$\begin{aligned}
\theta_1 &= 16.8584 \\
\theta_2 &= 23.7742 \\
\theta_3 &= 90.3410 \\
\theta_4 &= \theta_5 = \theta_6 = \infty
\end{aligned} \tag{3}$$

Part D

See appendix for the exact form of the T matrixs. Matlab was used to generate them. The jacobean of matrix was then found using the equation in the book.

$$J = \begin{bmatrix}
-a_2S_1C_2 - a_3S_1C_{23} & -a_2S_2C_1 - a_3S_{23}C_1 & -a_3S_{23}C_1 \\
a_2C_1C_2 + a_3C_1C_{23} & -a_2S_2S_1 - a_3S_{23}S_1 & -a_3S_1C_{23} \\
0 & a_2C_2 + a_3C_{23} & a_3C_{23} \\
0 & 0 & 0 \\
0 & 0 & 0 \\
1 & 1 & 1
\end{bmatrix} \tag{4}$$

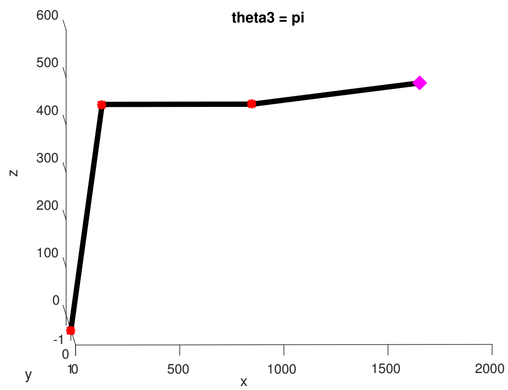
Part E

$$\dot{\vec{\theta}} = J^+\dot{\vec{x}} = [-0.026, 0.0471, -0.0211]^T \tag{5}$$

Part F

Taking the determent of Jacobian of reveals the singularities of the kinematic chain.

$$
\begin{aligned}
det(J) &= a_2 a_3 S_3(a_2 C_2 + a_3 C_{23}) = 0 \\
&\Rightarrow sin(\theta_3) = 0 \rightarrow \theta_3 = 0, \pi \\
&\Rightarrow a_2 C_2 + a_3 C_{23} = 0
\end{aligned} \tag{6}
$$



Extra Credit

see Appendix ($do_i k.m$)