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Lab 2 preparation

3.1 GeometricJacobian(robot, q)

H_i^{i-1}[] = forward(robot)

for i=1:6

  Zs[i] = H[i][1:3,3]

  Os[i] = H[i][1:3,4]

Jv[1] = $z_0^0 \times$ Os[6]

for i=2:6

  Jv[i] = Zs[i-1] x (Os[6] - Os[i-1])

J = Jv # $J = \begin{bmatrix} z_i^0 \times (O_6^0 - O_i^0) \\ z_i^0 \end{bmatrix}$

  Zs #

return J

3.2 AnalyticJacobian(robot, q)

H_6^0 = forward(robot)

$R_6^0 = H_6^0[1{:}3, 1{:}3] = R$

$$\phi = \text{atan2}(R_{23}, R_{13})$$

$$\theta = \text{atan2}(\sqrt{1-R_{33}^2}, R_{33})$$

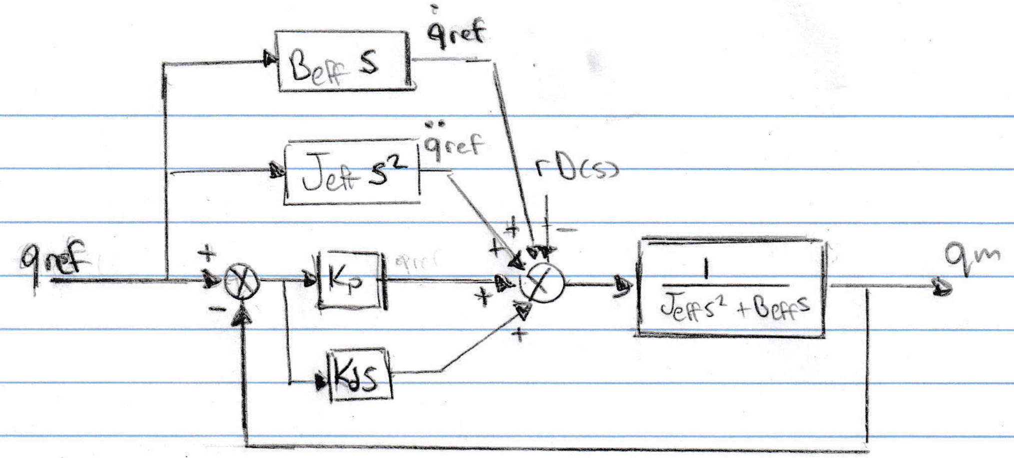
$$\psi = \text{atan2}\left(\frac{R_{32}}{\sin\theta}, \frac{-R_{31}}{\sin\theta}\right)$$

$$B = \begin{bmatrix} 0 & -s\phi & c\phi\, s\theta \\ 0 & c\phi & s\phi\, s\theta \\ 1 & 0 & c\theta \end{bmatrix}$$

$$J_a = \begin{bmatrix} I_3 & 0 \\ 0 & B^{-1} \end{bmatrix} \text{GeometricJacobian(robot, q)}$$

return Ja

5.



6. Using the characteristic polynomial $Js^2 + (B+K_d)s + K_p$

we can rearrange to get $s^2 + \frac{(B+K_d)}{J}s + \frac{K_p}{J} = 0$ at poles

Want this to equal $(s+2)^2 = 0$ for both poles to be -2

$= s^2 + 4s + 4$

$\Rightarrow \frac{B+K_d}{J} = 4 \Rightarrow B + K_d = 4J \Rightarrow \underline{K_d = 4J - B}$

$\Rightarrow \frac{K_p}{J} = 4 \Rightarrow \underline{K_p = 4J}$

Subbing in J & B from table into Kd/Kp formulas we get

$K_{p1} = 8e^{-4}$	$K_{d1} = -6.8e^{-4}$
$K_{p2} = 8e^{-4}$	$K_{d2} = -1.7e^{-5}$
$K_{p3} = 8e^{-4}$	$K_{d3} = -5.80e^{-4}$
$K_{p4} = 1.32e^{-4}$	$K_{d4} = 6.08e^{-5}$
$K_{p5} = 1.32e^{-4}$	$K_{d5} = 4.94e^{-5}$
$K_{p6} = 1.32e^{-4}$	$K_{d6} = 9.53e^{-5}$