Jacobiano.

$$\begin{bmatrix} V \\ W \end{bmatrix} = J(q)\dot{q}$$

$$dx = \frac{\partial(L_1C_1 + L_2C_{12})}{\partial\theta_1} + \frac{\partial(L_1C_1 + L_1C_{12})}{\partial\theta_2}$$

$x = L_1C_1 + L_2C_{12}$

$y = L_1S_1 + L_2S_{12}$

$$dx = (-L_1S_1 - L_2S_{12})d\theta_1 + (-L_1S_{12})d\theta_2$$

$$dy = (L_1C_1 + L_2C_{12})d\theta_1 + (L_2C_{12})d\theta_2$$

$$\begin{vmatrix} dx \\ dy \end{vmatrix} = \begin{vmatrix} -L_1S_{12} & -L_1S_{12} \\ L_1C_1 + L_2C_{12} & L_2C_{12} \end{vmatrix} \begin{vmatrix} d\theta_1 \\ d\theta_2 \end{vmatrix}$$

$$\begin{vmatrix} dx \\ dy \end{vmatrix} = \begin{vmatrix} -2S(30) - 2S(30+50) & -2S(30+50) \\ 2C(30) + 2C(30+50) & 2C(30+50) \end{vmatrix} \begin{vmatrix} 5 \\ 2 \end{vmatrix}$$

$$\begin{vmatrix} dx \\ dy \end{vmatrix} = \begin{vmatrix} -2{,}96 & -1{,}96 \\ 2{,}08 & 0{,}35 \end{vmatrix} = \begin{vmatrix} -18{,}72 \\ 11{,}1 \end{vmatrix} 0/s$$

junta

$$J_i = \begin{bmatrix} Z_{i-1} \times (O_n - O_{i-1}) \\ Z_{i-1} \end{bmatrix} \qquad J_i = \begin{bmatrix} Z_{i-1} \\ 0 \end{bmatrix}$$

Rotacional — Prismática.

$J = [J_1, J_2]$

$$J = \begin{bmatrix} Z_0 \times (O_2 - O_0) & Z_1 \times (O_2 - O_1) \\ Z_0 & Z_1 \end{bmatrix}$$

Link	a	α	d	θ
0-1	a_1	0	0	θ_1
1-2	a_2	0	0	θ_2

$${}^0A_1 = \begin{bmatrix} C_1 & -S_1 & 0 & a_1C_1 \\ S_1 & C_1 & 0 & a_1S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^0A_2 = \begin{bmatrix} C_{12} & -S_{12} & 0 & a_2C_{12} + a_1C_1 \\ S_{12} & C_{12} & 0 & a_2S_{12} + a_1S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$z_0 = R_0^0 k = k = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad O_2 = d_0^2 = \begin{bmatrix} a_2 c_{12} + a_1 c_1 \\ a_2 s_{12} + a_1 s_1 \\ 0 \end{bmatrix} \quad z_1 = R_0^1 k = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$O_1 = d_0^1 = \begin{bmatrix} a_1 c_1 \\ a_1 s_1 \\ 0 \end{bmatrix} \quad O_0 = d_0^0 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$J = \left[\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \left(\begin{pmatrix} a_2 c_{12} + a_1 c_1 \\ a_2 s_{12} + a_1 s_1 \\ 0 \end{pmatrix} - \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \right) \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \left(\right. \right.$$

$$J = \left(\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \left[\begin{pmatrix} 2{,}08 \\ 2{,}96 \\ 0 \end{pmatrix} - \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \right. \right.$$

Exercício 2:

Link	a	α	d	θ
0-1	0	90	d_1	θ_1^* 90=180
1-2	$a_2=2$	0	0	$\theta_2^* = 30$
2-3	$a_3=2$	0	0	$\theta_3^* = (-60)$

$${}^0A_1 = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad {}^0A_2 = \begin{bmatrix} -0{,}86 & 0{,}5 & 0 & -1{,}73 \\ 0 & 0 & 1 & 0 \\ -0{,}5 & 0{,}86 & 0 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad A_3^0 = \begin{bmatrix} -0{,}86 & -0{,}5 & 0 & -3{,}46 \\ 0 & 0 & 1 & 0 \\ -0{,}5 & 0{,}86 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$J = \begin{bmatrix} z_0 \times (O_3 - O_0) & z_1 \times (O_3 - O_1) & z_2 \times (O_3 - O_2) \\ z_1 & z_1 & z_2 \end{bmatrix}$$

$$z_0 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad z_1 = R_0^1 k \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad O_0 = d_0^0 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \quad O_3 = d_0^3 = \begin{bmatrix} -3{,}46 \\ 0 \\ 6 \end{bmatrix}$$

$$z_2 = R_0^2 k = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad O_1 = d_0^1 = \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

Jandaia

$$O_2 = d_0^2 = \begin{bmatrix} -1{,}73 \\ 0 \\ 3 \end{bmatrix}$$

$$J = \left[\begin{array}{ccc} \begin{bmatrix}0\\0\\1\end{bmatrix} \times \begin{bmatrix}-3{,}46 & 0\\ 0 & -0\\ 2 & 0\end{bmatrix} & \begin{bmatrix}0\\1\\0\end{bmatrix} \times \begin{bmatrix}-3{,}46 & 0\\ 0 & -0\\ 2 & 0\end{bmatrix} & \begin{bmatrix}0\\1\\0\end{bmatrix} \times \begin{bmatrix}-3{,}46 & 1{,}73\\ 0 & -0\\ 2 & 3\end{bmatrix} \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{array}\right.$$

$$\begin{bmatrix}V\\W\end{bmatrix} = \begin{bmatrix}0 & 0 & -1\\ -3{,}46 & 0 & 0\\ 0 & 3{,}46 & 1{,}73\\ 0 & 0 & 0\\ 0 & 1 & 1\\ 1 & 0 & 0\end{bmatrix}\begin{bmatrix}4\\3\\1\end{bmatrix} = \begin{array}{l}\left[\begin{array}{c}-1\\ -13{,}84\\ 12{,}11\\ 0\\ 4\\ 4\end{array}\right.\begin{array}{l}\to V_x\\ \to V_y\\ \to V_z\\ \to W_x\\ \to W_y\\ \to W_z\end{array}\end{array}$$

Questão 2 (Lista 8)

H_n^0

$H_0^2 = H_0^1 \cdot H_1^2$

$H_0^3 = H_0^1 \cdot H_1^2 \cdot H_2^3$

Trabalho Robótica 2° Parte

Cálculo do jacobiano.

$J = [J_1 \quad J_2 \quad J_3 \quad J_4 \quad J_5 \quad J_6]$

$$J = \begin{bmatrix} z_0 \times (O_6 - O_0) & \dots & z_5 \times (O_6 - O_5) \\ z_0 & & z_5 \end{bmatrix}$$

Tabela de Denavit-Hartenberg

substituir θ

$z_0 =$ $\quad$ $O_0 =$

$z_1 =$ $\quad$ $O_1 =$

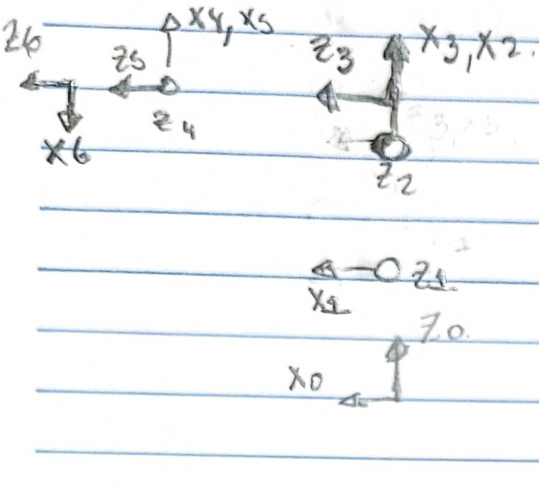
$z_2 =$ $\quad$ $O_2 =$

$J = [\quad]$

a) seja Jacobiano para:

$\theta_1 = \circ$ $\quad \theta_2 =$ $\quad \theta_3 =$

b)



Denavit - Hartenberg

Link	a	α	d	θ
0-1	0			
1-2	a2			
2-3	a3			
3-4				
4-5				
5-6				

$\dot{\theta}(t) = 10{,}8t - 2{,}16t^2$

$\theta(t) = 30 + 5{,}4t^2 + 0{,}72t^3$

$\theta(t) = C_0 + C_1 t + C_2 t^2 + C_3 t^3$

$\theta(t_i) = 30 = C_0 + C_1(0) + C_2(0)^2 + C_3(0)^3$

obs: $t_i = 0$ $\quad \boxed{C_0 = 30}$

$\theta(t_f) = 75 = C_0 + C_1(5) + C_2(5)^2 + C_3(5)^3$

$t_f = 5s$ $\quad 75 = 30 + 5C_1 + 25C_2 + 125C_3$

$5C_1 + 25C_2 + 125C_3 = 45$

$\dot{\theta}(t) = C_1 + 2C_2 t + 3C_3 t^2$

$\dot{\theta}(t_i) = 0 = C_1 + 2C_2(0) + 3C_3(0)^2$

$\boxed{C_1 = 0}$

$\dot{\theta}(t_f) = 0 = C_1 + 2C_2(5) + 3C_3(5)^2$

$10C_2 + 75C_3 = 0$

$\begin{cases} 25C_2 + 125C_3 = 45 \\ 10C_2 + 75C_3 = 0 \end{cases} = \begin{vmatrix} 25 & 125 \\ 10 & 75 \end{vmatrix} \begin{vmatrix} C_2 \\ C_3 \end{vmatrix} = \begin{vmatrix} 45 \\ 0 \end{vmatrix}$

$C_2 = 5{,}4$

$C_3 = -0{,}72$

Exercício

$\theta(t) = C_0 + C_1 t + C_2 t^2 + C_3 t^3$

$\theta(t_i) = 75 = C_0 + C_1(0) + C_2(0)^2 + C_3(0)^3$

$C_0 = 75$

$\theta(t_f) = 105 = C_0 + C_1(3) + C_2(3)^2 + C_3(3)^3$

$3C_1 + 9C_2 + 27C_3 = 30$

$\dot{\theta}(t_i) = C_1 + 2C_2 t + 3C_3 t^2$

$0 = C_1 + 2C_2(0) + 3C_3(0)^2$

$\boxed{C_1 = 0}$

$\dot{\theta}(t_f) = 0 = \cancel{C_1} + 2C_2(3) + 3C_3(3)^2$

$6C_2 + 27C_3 = 0$

$\begin{cases} 9C_2 + 27C_3 = 0 \\ 6C_2 + 27C_3 = 0 \end{cases} \Rightarrow C_2 = 10, \quad C_3 = -2{,}22$

$\theta(t) = 75 + 10t^2 - 2{,}22t^3$

$\dot{\theta}(t) = 20t - 6{,}66t^2$

Exercício 3

$\theta(t) = c_0 + c_1 t + c_2 t^2 + c_4 t^4 + c_5 t^5$

Cond. Iniciais $\begin{cases} t_i = 0 & t_f = 5 \\ \theta(t_i) = 30 & \theta(t_f) = 75 \\ \ddot{\theta}(t_i) = 5°/s & \ddot{\theta}(t_f) = 5°/s \end{cases}$

$\theta(t_i) = 30 = c_0 + c_1(0) + c_2(0)^2 + c_3(0)^3 + c_4(0)^4 + c_5(0)^5$

$t_i = 0$ $\boxed{c_0 = 30}$

$\dot{\theta}(t_i) = 0 = c_1 + 2c_2(0) + 3c_3(0)^2 + 4c_4(t)^3 + 5c_5(0)^4$

$\boxed{c_1 = 0}$

$\ddot{\theta}(t_i) = 5 = 2c_2 + 6c_3(0) + 12c_4(0)^2 + 20c_5(0)^3$

$2c_2 = 5$

$\boxed{c_2 = 2{,}5}$

$\theta(t_f) = 30 + 0(5) + 2{,}5(5)^2 + c_3(5)^3 + c_4(5)^4 + c_5(5)^5$

$75 = 30 + 62{,}5 + 125c_3 + 625c_4 + 3125c_5$

$125c_3 + 625c_4 + 3125c_5 = 17{,}5$

$\dot{\theta}(t_f) = 0 = 0 + 2(2{,}5)(5) + 3c_3(5)^2 + 4c_4(5)^3 + 5c_5(5)^4$

$75c_3 + 500c_4 + 3125c_5 = -25$

$\ddot{\theta}(t_f) = -5 = 2(2{,}5) + 6c_3(5) + 12c_4(5)^2 + 20c_5(5)$

$30c_3 + 300c_4 + 2500c_5 = -10$

$\begin{cases} 125c_3 + 625c_4 + 3125c_5 = -17{,}5 \\ 75c_3 + 500c_4 + 3125c_5 = -25 \\ 30c_3 + 300c_4 + 2500c_5 = -10 \end{cases}$

$c_3 = 1{,}6$

$c_4 = -0{,}58$

$c_5 = 0{,}0464$

$\begin{cases} \theta(t) = 30 + 2{,}5t^2 + 1{,}6t^3 - 0{,}58t^4 + 0{,}0464t^5 \\ \dot{\theta}(t) = 5t + 4{,}8t^2 - 2{,}32t^3 + 0{,}232t^4 \\ \ddot{\theta}(t) = 5 + 9{,}6t - 6{,}96t^2 + 0{,}928t^3 \end{cases}$

(4) antropomórfico RRR

~~$\theta(t) = C_0 + C_1 t + C_2 t^2 + C_3 t^3 + C_4 t^4 + C_5 t^5$~~

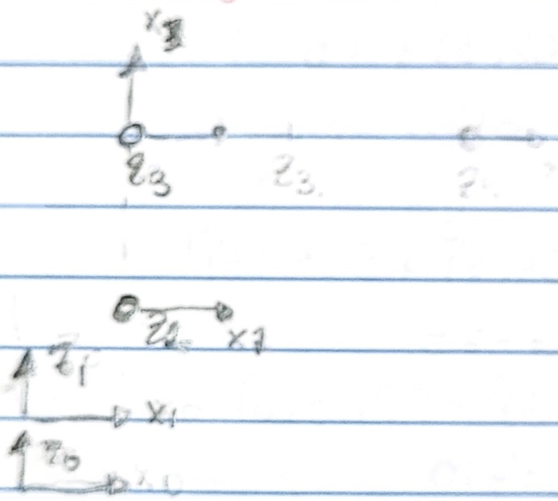
junta 1 = $\theta(t) = 3{,}06\,t^2 - 0{,}2915\,t^3$

junta 2 = $\phi(t) = 2{,}6239\,t^3 - 0{,}5623\,t^4 + 0{,}0321\,t^5$

junta 3 = $\theta(t) = 2{,}2915\,t^3 - 0{,}0625\,t^4 + 0{,}0036\,t^5$

Lista de Revisão

(1)



motoman MH5F

	a	α	d	θ	
0-1	88	-90	330	50	
1-2	310	±180	0	$(\theta_2^*) - 90$	
2-3	40	-90	0	$\theta_3 = 80$	
3-4	0	90	-305	$\theta_4 = 90$	
4-5	0	-90	0	$\theta_5 = 0$	
5-6	0	0	-80	$\theta_6 = 20$	

$J = [J_1 \ldots J_6]$

$$J = \begin{bmatrix} z_0 \times (O_6 - O_0) & \cdots & z_5 \times (O_6 - O_5) \\ z_0 & & z_5 \end{bmatrix}$$

$Z_0 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ $Z_3 = \begin{bmatrix} -0,11 \\ -0,13 \\ -0,98 \end{bmatrix}$ $O_0 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ $O_3 = \begin{bmatrix} 31, \\ \\ \end{bmatrix}$

$Z_1 = \begin{bmatrix} -0,76 \\ 0,64 \\ 0 \end{bmatrix}$ $Z_4 = \begin{bmatrix} -0,63 \\ -0,75 \\ 0,17 \end{bmatrix}$ $O_1 = \begin{bmatrix} 56,56 \\ 67,41 \\ 330 \end{bmatrix}$

$Z_2 = \begin{bmatrix} 0,76 \\ -0,64 \\ 0 \end{bmatrix}$ $Z_5 = \begin{bmatrix} -0,11 \\ -0,13 \\ -0,98 \end{bmatrix}$ $O_2 = \begin{bmatrix} 56,56 \\ 67,41 \\ 640 \end{bmatrix}$

///

2 DOF

Rot (x, a) Trans $(0, 0, d)$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & Ca & -sa & -dsa \\ 0 & sa & Ca & dCa \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ → derivada é = ao Jacobiano.

$px = 0 \Rightarrow \dot{p}x = 0$

$py = -dsa \Rightarrow \dot{p}y = \dfrac{\partial(-dsa)}{\partial d} + \dfrac{\partial(-dsa)}{\partial a} = -sa\partial d - dca\partial a$

$\Rightarrow$ ①

$pz = dca \Rightarrow \dot{p}z = \dfrac{\partial(dca)}{\partial d} + \dfrac{\partial(dca)}{\partial a} \Rightarrow ca\partial d - dsa\partial a$

① $\begin{vmatrix} \dot{p}x \\ \dot{p}y \\ \dot{p}z \end{vmatrix} = \begin{vmatrix} -sa & -dca \\ ca & -dsa \end{vmatrix} \begin{vmatrix} \partial d \\ \partial a \end{vmatrix}$

P_x	P_y	P_z			
8	6	10	θ_1	θ_2	θ_3
8,4	5,9	9,8			
7,8	5,8	9,6			

3	5	8