Manipolatore di Stanford

$$\tau = K_p e + K_d \dot{e} + G(q) \tag{1}$$

$$K_p = \begin{bmatrix} 1000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 100 & 0 & 0 & 0 \\ 0 & 0 & 0 & 100 & 0 & 0 \\ 0 & 0 & 0 & 0 & 100 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{bmatrix} \tag{2}$$

$$K_d = \begin{bmatrix} 10 & 0 & 0 & 0 & 0 & 0 \\ 0 & 100 & 0 & 0 & 0 & 0 \\ 0 & 0 & 10 & 0 & 0 & 0 \\ 0 & 0 & 0 & 10 & 0 & 0 \\ 0 & 0 & 0 & 0 & 10 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{bmatrix} \tag{3}$$

$$\tau = B(q)[\ddot{q}_d + K_p e + K_d \dot{e}] + C(q, \dot{q})\dot{q} + G(q) \tag{4}$$

$$K_p = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

$$K_d = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{6}$$

$$\tau = Y\hat{\pi} + K_d \dot{e} + K_p e \tag{7}$$

$$u_\pi = R^{-1} Y^T M^{-T} B^T P x \tag{8}$$

$$K_p = \begin{bmatrix} 1000 & 00 & 0 & 0 & 0 & 0 \\ 0 & 10000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 10000 & 0 & 0 & 0 \\ 0 & 0 & 0 & 10000 & 0 & 0 \\ 0 & 0 & 0 & 0 & 10000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{bmatrix} \tag{9}$$

$$K_d = \begin{bmatrix} 100 & 00 & 0 & 0 & 0 & 0 \\ 0 & 1000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1000 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1000 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{bmatrix} \tag{10}$$

$$R = I_6 \tag{11}$$

$$A = \begin{bmatrix} 0_6 & I_6 \\ -K_p & -K_d \end{bmatrix} \tag{12}$$

$$B = \begin{bmatrix} 0_6 \\ I_6 \end{bmatrix} \tag{13}$$

$$Q = I_{12} \tag{14}$$

$$A^T P + PA = -Q \tag{15}$$

Granty crane

$$\ddot{\theta} D + [\ddot{x} l cos\theta + g l sin\theta] B = -b_1 \dot{\theta} \tag{16}$$

$$\ddot{x} C + [\ddot{x} l cos\theta + g l sin\theta] B = F - b_2 \dot{x} \tag{17}$$

$$B = m_1 + \frac{1}{3} m_2 \tag{18}$$

$$C = m_1 + m_2 + M \tag{19}$$

$$D = \frac{2}{5} m_1 r^2 \tag{20}$$

$$\mathbf{q} = \begin{bmatrix} \theta \\ \dot{\theta} \\ x \\ \dot{x} \end{bmatrix} \tag{21}$$

$$\begin{cases} \dot{q_0} = q_1 \\ \dot{q_1} = \frac{-b_1 q_1}{D} - \frac{glsin(q_0)B}{D} + \frac{(b_2 q_3 + glsin(q_0)B)(lcos(q_0)B)}{(C + lcos(q_0)B)D} - \frac{Flcos(q_0)B}{(C + lcos(q_0)B)D} \\ \dot{q_2} = q_3 \\ \dot{q_3} = \frac{(-b_2 q_3 - glsin(q_0)B)}{C + lcos(q_0)B} + \frac{F}{C + lcos(q_0)B} \end{cases}$$

$$\dot{q} = f(q) + g(q)u \tag{22}$$

$$y = h(q) \tag{23}$$

$$\mathbf{f}(\mathbf{q}) = \begin{bmatrix} q_1 \\ \frac{-b_1 q_1}{D} - \frac{glsin(q_0)B}{D} + \frac{(b_2 q_3 + glsin(q_0)B)(lcos(q_0)B)}{(C + lcos(q_0)B)D} \\ q_3 \\ \frac{(-b_2 q_3 - glsin(q_0)B)}{C + lcos(q_0)B} \end{bmatrix} \tag{24}$$

$$\mathbf{g}(\mathbf{q}) = \begin{bmatrix} 0 \\ -\frac{Flcos(q_0)B}{(C + lcos(q_0)B)D} \\ 0 \\ \frac{F}{C + lcos(q_0)B} \end{bmatrix} \tag{25}$$

$$\mathbf{h}(\mathbf{q}) = q_0 = \theta \tag{26}$$

$$\mathbf{h}(\mathbf{q}) = q_2 = x \tag{27}$$

$$\mathbf{h}(\mathbf{q}) = q_2 + lsin(q_0) \tag{28}$$

$$\mathbf{\Delta} = \begin{bmatrix} 0 & * & * & * & * \\ * & * & * & * & * \\ 0 & * & * & * & * \\ * & * & * & * & * \end{bmatrix} \tag{29}$$

$$\mathbf{dO} = \begin{bmatrix} * & 0 & 1 & 0 \\ * & * & 0 & 1 \\ * & 0 & 0 & 0 \\ * & * & 0 & 0 \\ * & * & 0 & 0 \\ * & 0 & 0 & 0 \end{bmatrix} \tag{30}$$

$$\mathbf{dO} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ * & 0 & 0 & * \\ * & 0 & 0 & 0 \end{bmatrix} \tag{31}$$

$$\mathbf{dO} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ * & * & 0 & * \\ * & 0 & 0 & 0 \end{bmatrix} \tag{32}$$

$$\mathbf{z} = \begin{bmatrix} h \\ L_f h \\ q_0 \\ \frac{-1}{lcosq_0 B} q_1 + q_3 \end{bmatrix} \tag{33}$$

$$\dot{\mathbf{z}} = \begin{bmatrix} L_f h \\ L_f^2 h + L_g L_f h u \\ \dot{q_0} \\ \frac{\partial z_3}{\partial q}(f + gu) \end{bmatrix} \tag{34}$$

$$\mathbf{u} = \frac{v + L_f^2 h}{L_g L_f h} \tag{35}$$