# Cinemática Inversa

- $t_x = -3 = l_1 c_1 + l_2 c_{12} + l_3 c_{123}$
- $t_y = 2 = l_1 s_1 + l_2 s_{12} + l_3 s_{123}$
- $t_z = 0$

$$\begin{matrix} t_x - l_3 a_x = t_x' = l_1 c_1 + l_2 c_{12} \\ t_y - l_3 a_y = t_y' = l_1 s_1 + l_1 s_{12} \end{matrix} \Leftrightarrow \begin{cases} t_x'^2 = l_1^2 c_1^2 + l_2^2 c_{12}^2 + 2 l_1 l_2 c_1 c_{12} \\ t_y'^2 = l_1^2 s_1^2 + l_2^2 s_{12}^2 + 2 l_1 l_2 s_1 s_{12} \end{cases}$$

$$t_x'^2 + t_y'^2 = l_1^2 + l_2^2 + 2 l_1 l_2 \underbrace{(c_1 c_{12} + s_1 s_{12})}_{c_2}$$

$$c_2 = \frac{t_x'^2 + t_y'^2 - l_1^2 - l_2^2}{2 l_1 l_2}$$

$$\boxed{\theta_2 = \pm \operatorname{acos}\left(\frac{t_x'^2 + t_y'^2 - l_1^2 - l_2^2}{2 l_1 l_2}\right)}$$

$$\begin{aligned} c_1 c_{12} + s_1 s_{12} &= c(\theta_1 - (\theta_1 + \theta_3)) = \\ &= c(\theta_1 - \theta_2 - \theta_3) = \\ &= c(-\theta_2) = c(\theta_2) \end{aligned}$$

$$\theta_1 + \theta_2 + \theta_3 = \operatorname{artan}^2(a_y, a_x)$$

$$\boxed{\theta_3 = \operatorname{artg}^2(a_y, a_x) - \theta_1 - \theta_2}$$

$${}^{0}_{1}T \cdot {}^{1}_{2}T = [\, n' \; s' \; a' \; t' \,] \Leftrightarrow \begin{bmatrix} c_1 & -s_1 & 0 & l_1 c_1 \\ s_1 & c_1 & 0 & l_1 s_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot$$

$$= \begin{bmatrix} n_x' & s_x' & a_x' & t_x' \\ n_y' & s_y' & a_y' & t_y' \\ n_z' & s_z' & a_z' & t_z' \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} c_2 & s_2 & 0 & l_2 \\ s_2 & c_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$