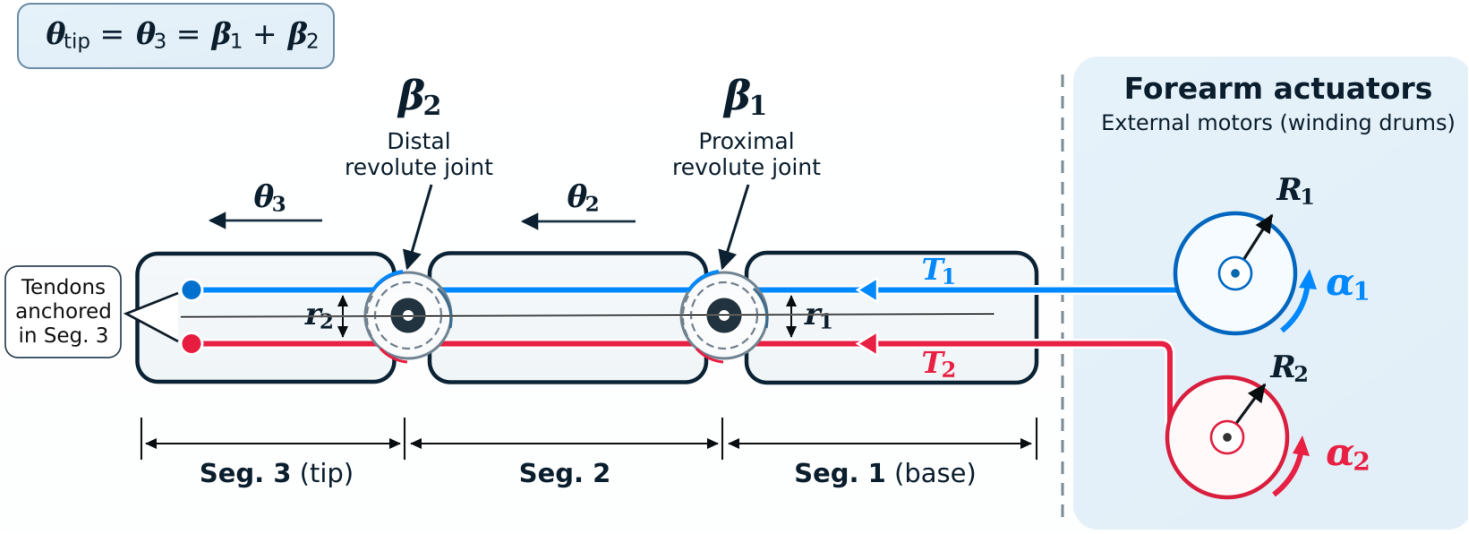


Tendon displacement

$$d_{\text{tendons},i} = 2r_i$$

$$\boxed{\Delta L = r_1\beta_1 + r_2\beta_2}$$

$$\Delta L_{\text{upper}} = +\Delta L$$

$$\Delta L_{\text{lower}} = -\Delta L$$

External motor angles

$$\boxed{\alpha_1 = -\frac{r_1\beta_1 + r_2\beta_2}{R_1}}$$

$$\boxed{\alpha_2 = +\frac{r_1\beta_1 + r_2\beta_2}{R_2}}$$

$$R_1\alpha_1 + R_2\alpha_2 = 0$$

Assuming $r_1 = r_2$

$$r_1 = r_2 = r$$

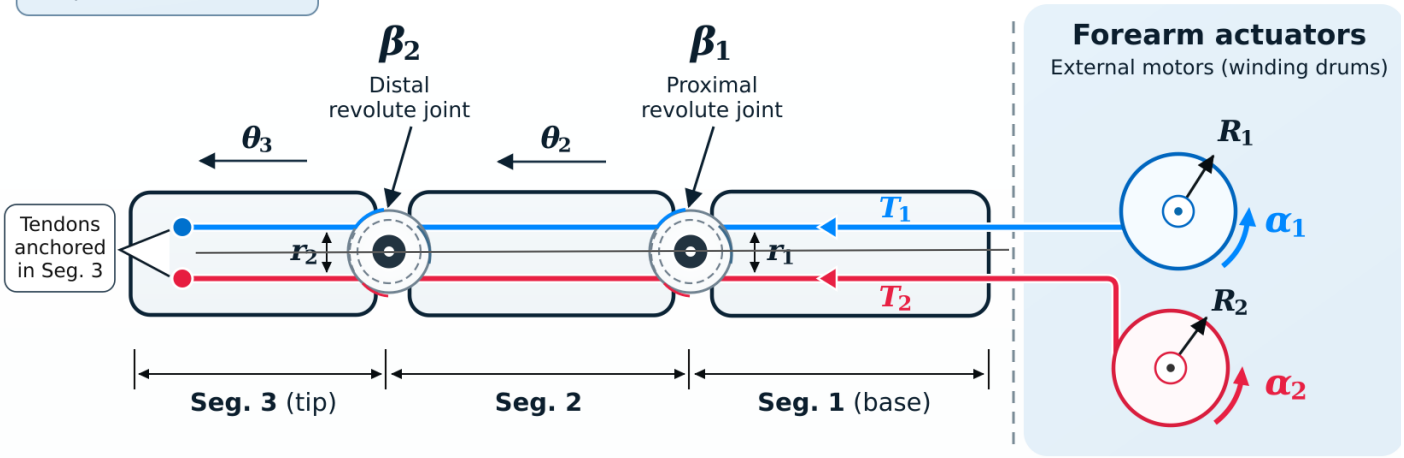
$$\boxed{\Delta L = r(\beta_1 + \beta_2)}$$

$$\alpha_1 = -\frac{r}{R_1}(\beta_1 + \beta_2)$$

$$\alpha_2 = +\frac{r}{R_2}(\beta_1 + \beta_2)$$

$$R_1 = R_2 = R \implies \alpha_1 = -\alpha_2$$

$\boldsymbol{\theta}_{\text{tip}} = \boldsymbol{\theta}_3 = \boldsymbol{\beta}_1 + \boldsymbol{\beta}_2$



$$\begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix} = \begin{bmatrix}-\dfrac{r_1}{R_1} & -\dfrac{r_2}{R_1}\\ +\dfrac{r_1}{R_2} & +\dfrac{r_2}{R_2}\end{bmatrix}\begin{bmatrix}\beta_1\\ \beta_2\end{bmatrix}$$

$$\operatorname{rank}(J_{\text{tendon}}) = 1$$

$$\boxed{\beta_2 = \frac{R_2\alpha_2 - r_1\beta_1}{r_2}}$$

$$\boxed{\tau_1 = \tau_{\text{servo},1} + r_1(T_2 - T_1)}$$

$$\boxed{\tau_2 = \tau_{\text{servo},2} + r_2(T_2 - T_1)}$$