$ijk = -1$

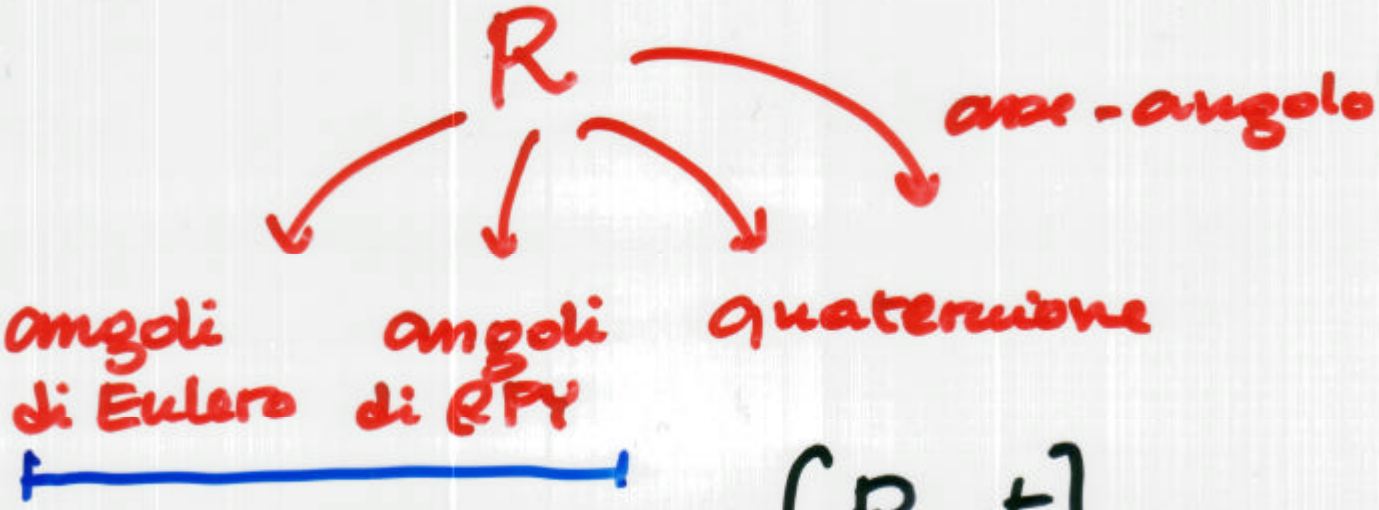
ϕ, θ, ψ Eulero

$R(k, \phi) R(i, \theta) R(k, \psi)$

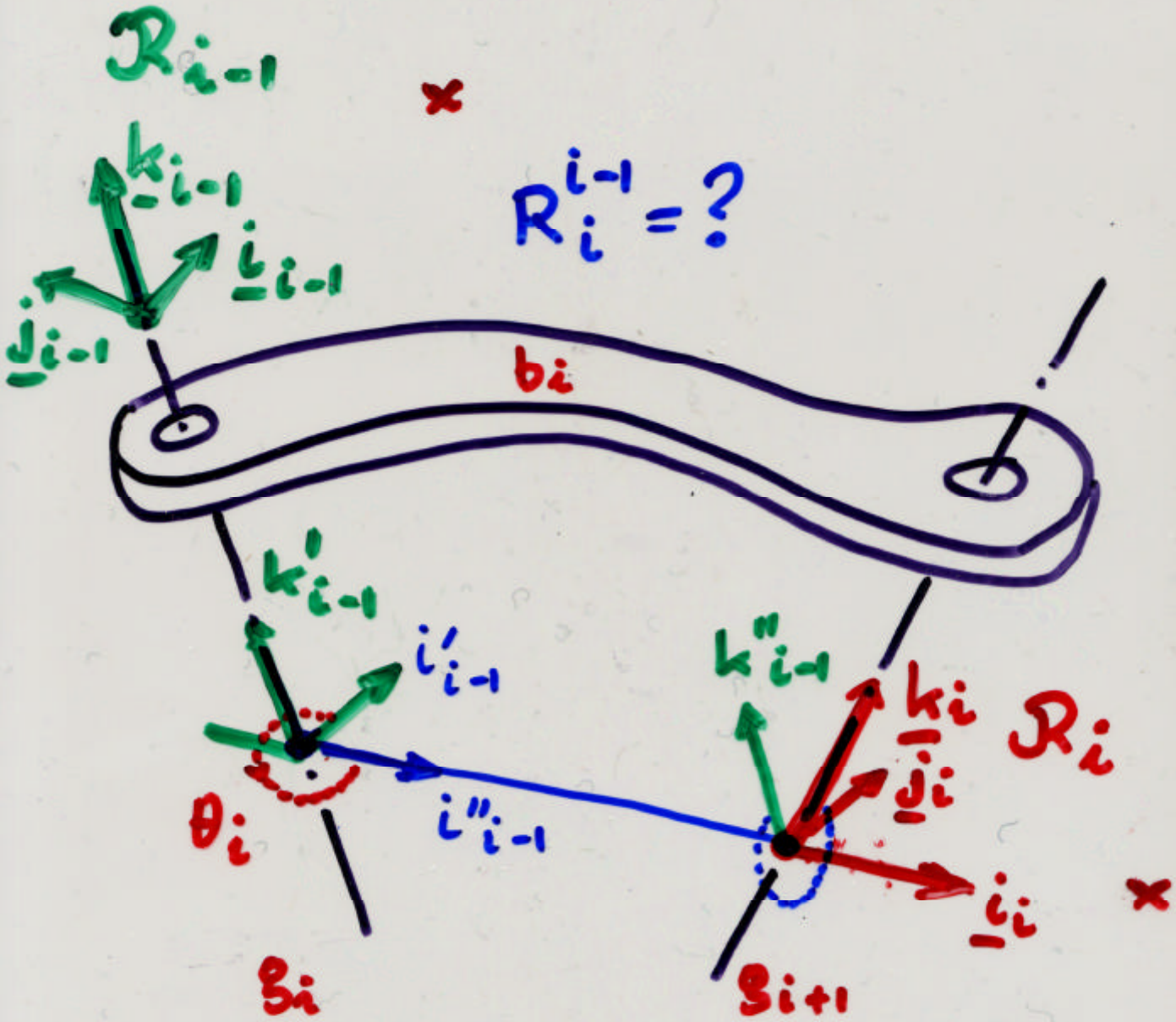
Roll - Pitch - Yaw

$\theta_x, \theta_y, \theta_z$

$R(k, \theta_z) R(j, \theta_y) R(i, \theta_x)$



$$T = \begin{bmatrix} R & t \\ \cdots & \cdot \end{bmatrix}$$



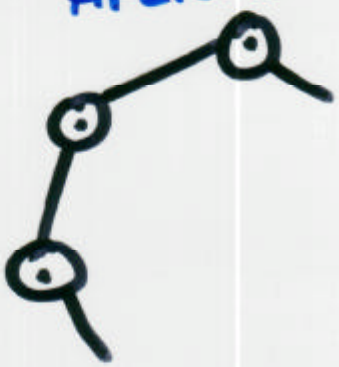
$$\text{Trasl}(d_i, \underline{k}) \, \text{Rot}(q_i(t), \underline{k})$$

$$\hookrightarrow \text{Trasl}(a_i, \underline{i}) \, \text{Rot}(\alpha_i, \underline{i})$$

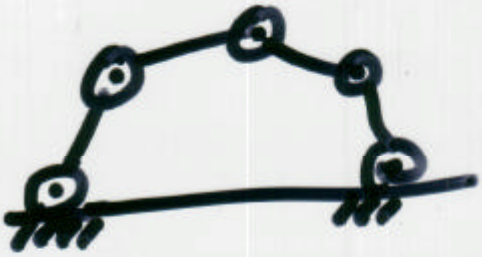
Convenzioni di Denavit-Hartenberg

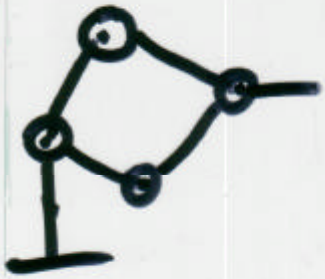
CATENA CINEMATICA APERTA

APERTE



CHIUSE





GIUNTO 1 g_1
BRACCIO 1 b_1
GIUNTO 2 g_2
BRACCIO 2 b_2
⋮ ⋮

g_i b_i g_{i+1}

b_0 terra
b_6 ultimo

n giunti
b_n ultimo

n giunti n R_i

$R_0, R_1, R_2, \dots, R_6$

$R_i(O_i, \underline{i}_i, \underline{j}_i, \underline{k}_i)$

- O_i è posta lungo l'asse di movimento del giunto g_{i+1}
  nel punto di intersezione tra g_{i+1} e il segmento a minima distanza da g_i
- $\underline{k}_i$ è allineato con g_{i+1}
- $\underline{i}_i$ è posto $\perp$ a $\underline{k}_{i-1}$
- $\underline{j}_i$ completa la terna

PARAMETRI DI D-H

d_i	$d_i = q_i(t)$
$\theta_i = q_i(t)$	θ_i
a_i	a_i
α_i	α_i
↑	↑
Rotoidale	Prismatico

$$T_i^{i-1} = \begin{bmatrix} I & \underline{d} \\ \underline{0}^T & 1 \end{bmatrix} \begin{bmatrix} R(\underline{k}, \theta_i) & \underline{0} \\ \underline{0}^T & 1 \end{bmatrix} \begin{bmatrix} I & \underline{a} \\ \underline{0}^T & 1 \end{bmatrix} *$$

$$\underline{d} = \begin{bmatrix} 0 \\ 0 \\ d_i \end{bmatrix} \qquad \underline{a} = \begin{bmatrix} a_i \\ 0 \\ 0 \end{bmatrix}$$

$$* \begin{bmatrix} R(\underline{i}, \alpha_i) & \underline{0} \\ \underline{0}^T & 1 \end{bmatrix}$$

$q_i \rightarrow$ Coordinata giunto

$$\underline{q} = \begin{bmatrix} q_1 \\ \vdots \\ q_n \end{bmatrix} = \underline{q}(t)$$

$$T_1^0 T_2^1 T_3^2 T_4^3 T_5^4 T_6^5 = T$$

$$T = \begin{bmatrix} R & t \\ 0\ 0\ 0 & 1 \end{bmatrix}$$

$\rightsquigarrow$ 6 parametri

R_6^0 ? $\quad t_6^0$ $\quad \|t_6^0\| = ?$

$\mathcal{R}_0 \rightarrow \mathcal{R}_6$ dato da R_6^0

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{\text{PUNTA}} = \begin{bmatrix} t_6^0 \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{\text{PUNTA}} = \underline{t}_b^0 = t_b^0(t) \Rightarrow$$

$$\underline{t}_b^0 = \underline{t}_b^0(q_1(t), q_2(t), \dots, q_6(t))$$

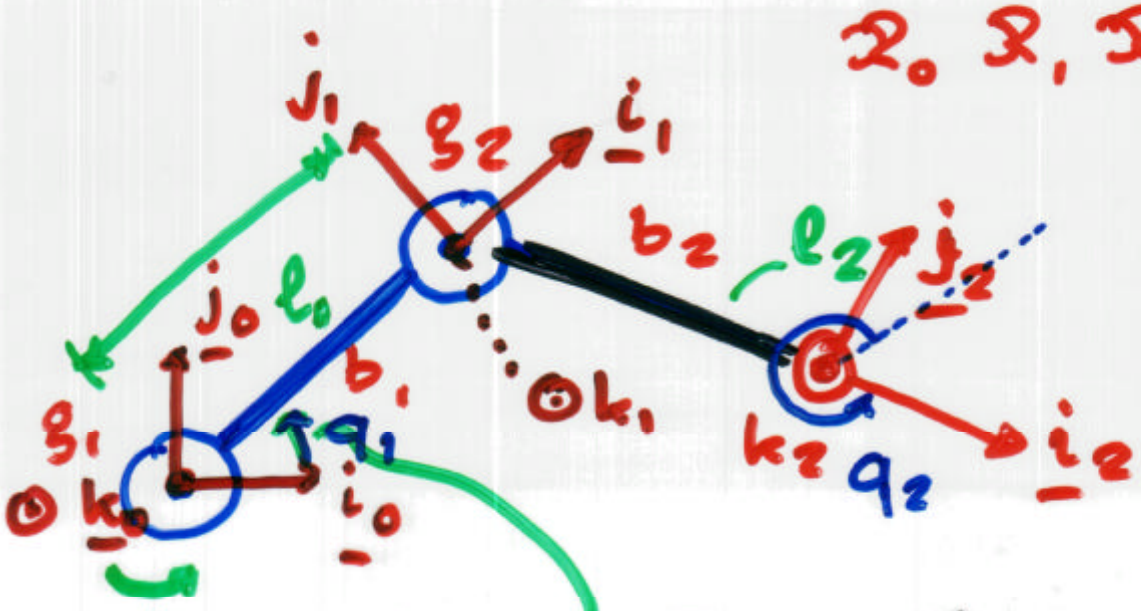
$$= \underline{t}_b^0(\underline{q}(t))$$

FUNZIONE CINEMATICA DIRETTA DI POSIZIONE

$$\underline{p}(t) = f(\underline{q}(t))$$

$$\underline{p} = \begin{bmatrix} p_1 \\ \vdots \\ p_6 \end{bmatrix} = \begin{bmatrix} x \\ \dots \\ \alpha \end{bmatrix}_3^3 = f(\underline{q}(t)) = \begin{bmatrix} t_b^0 \\ \dots \\ ? \end{bmatrix}$$

$\mathcal{R}_0\ \mathcal{R}_1\ \mathcal{R}_2$



$d_1 = 0$

$a_1 = l_1$

$\alpha_1 = 0$

q_1 ?

$d_2 = 0$

$a_2 = l_2$

$\alpha_2 = 0$

q_2 ?