$s(t) \quad \dot{s}(t) \quad \ddot{s}(t) \quad \dots$

$$\downarrow$$

$s_k \quad \dot{s}_k \quad \ddot{s}_k \quad \dots$

$$\downarrow$$

$$\underline{x}_k = \underline{x}_0 + s_k(\underline{x}_f - \underline{x}_0)$$

VARIABILI ANGOLARI ?

$$R(t) \rightarrow R_k$$

$$R_k = \boxed{R_0 + s_k(R_f - R_0)}$$

NON È CORRETTO

deve essere $R_k^T R_k = I$

non garantisce
la proprietà
salvo che per moti piani

3 METODI

1° ANGOLI EULERO (o SIMILI)

$$R_0 \; ; \; R_f$$

$$\downarrow \qquad \downarrow$$

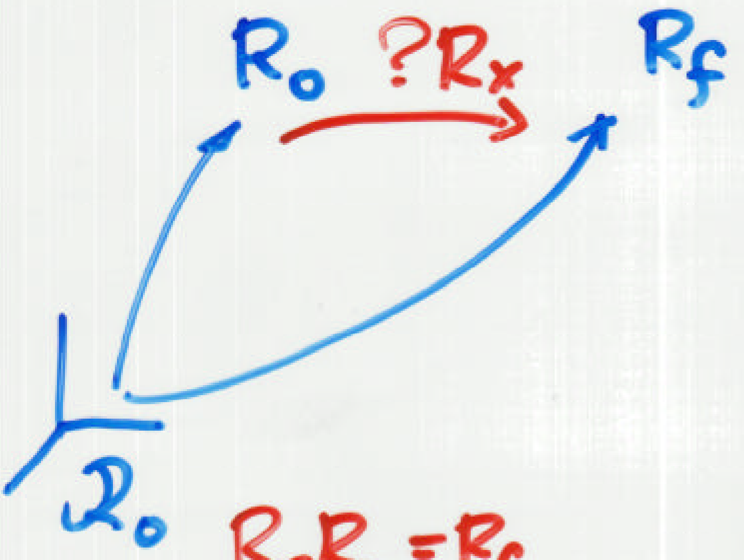
$$\varphi_0 \theta_0 \psi_0 \qquad \varphi_f \, \theta_f \, \psi_f$$

$$\varphi_k = \varphi_0 + s_k(\varphi_f - \varphi_0)$$

$$\theta_k = \theta_0 + s_k(\theta_f - \theta_0)$$

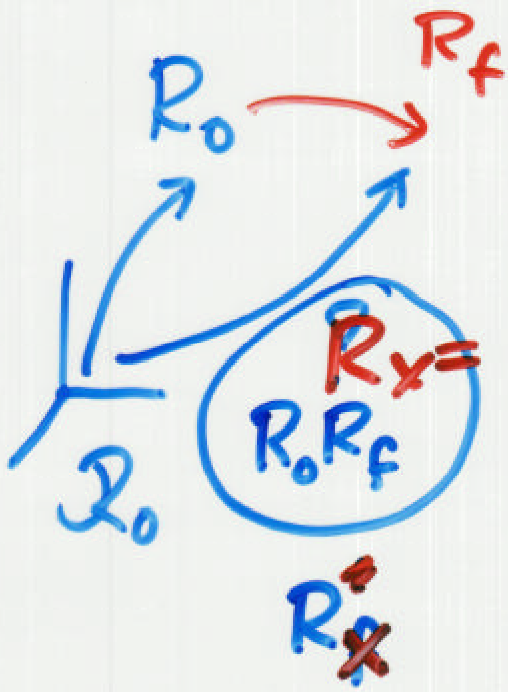
$$\psi_k = \psi_0 + s_k(\psi_f - \psi_0)$$

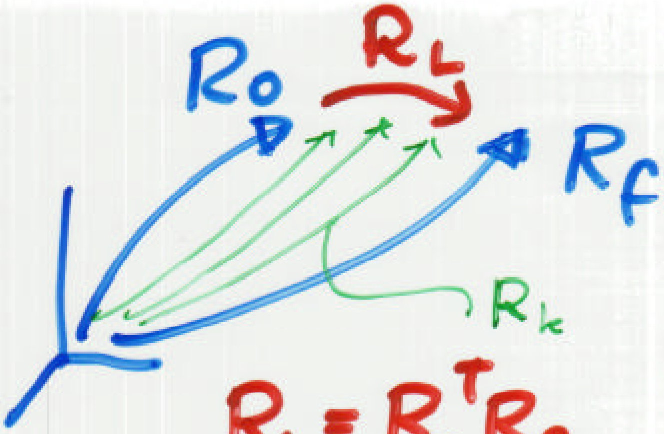
3° ASSE ANGOLO

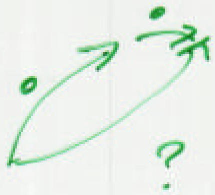


$$R_0 R_x = R_f$$

$$R_x = R_0^T R_f$$







$$R_L = R_0^T R_f$$

$\Downarrow$ estrarre

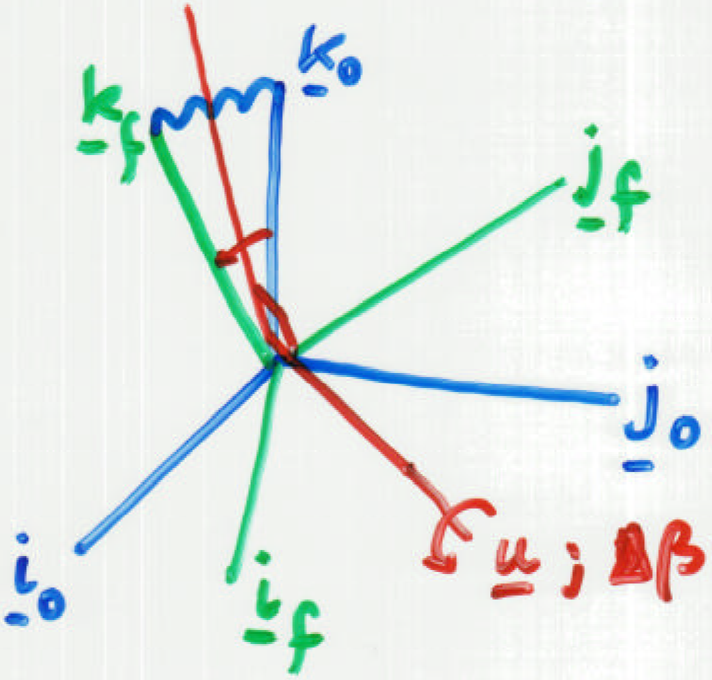
$\underline{u}$; θ_f

$\underline{u}$ è costante

$$\theta_k = \underset{\substack{\downarrow \\ =0}}{\theta_0} + s_k(\theta_f - \underset{\substack{\downarrow \\ =0}}{\theta_0})$$

$R_{L,k}(\underline{u}, \theta_k)$ ← locale; "relativa" "incrementale"

$R_k = R_0 R_{L,k}$ ← assoluta



Composizione di 2 moti di rotazione

- scivolamento di $\underline{k}(t)$ sul piano $\underline{k}_0 \underline{k}_f$
- rotazione intorno a $\underline{k}(t)$

DATI R_0 ; R_f ASSOLUTI ENTRAMBI

$\underline{k}_0$; $\underline{k}_f$? 3^a colonna

$$\underline{u} = \frac{\underline{k}_0 \times \underline{k}_f}{\| \cdot \|}$$

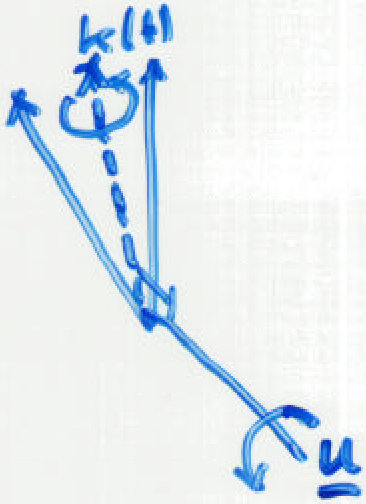
$$\Delta\beta = \arcsin \| \underline{k}_o \times \underline{k}_f \|$$

$$\underline{u} = \frac{\underline{k}_o \times \underline{k}_f}{\| \cdot \|}$$

$R(\underline{u}, \underline{\Delta\beta}) \rightarrow$ va campionata

$$\Delta\beta_k = \underset{\substack{\shortparallel \\ 0}}{\Delta\beta_o} + s_k(\Delta\beta - \underset{\substack{\shortparallel \\ 0}}{\Delta\beta_o})$$

$R_k(u, \Delta\beta_k)$ 1ª rotazione



$$Rot(\underline{k}, \Delta\alpha) = \begin{bmatrix} \cos\Delta\alpha & -\sin\Delta\alpha & 0 \\ \sin\Delta\alpha & \cos\Delta\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\Delta\alpha$?

$\Delta\alpha$

$$\Delta\alpha = \arcsin \| \underline{\tilde{\dot{j}}}_0 \times \underline{\dot{j}}_f \|$$

$\tilde{\dot{j}}_0$ dove si è portato $\dot{j}$ al termine della rotazione $R(\underline{u}, \Delta\beta)$

$$\underline{\dot{j}}_0 = R(u, \Delta\beta)\, \underline{\tilde{\dot{j}}}_0$$

$$\downarrow$$

$$\tilde{\dot{j}}_0 = R^T(u, \Delta\beta)\, \dot{j}_0$$

$\dot{j}_f =$ da R_f

$R_k(\underline{k}, \Delta\alpha)$?

$\Delta\alpha_k = 0 + s_k \Delta\alpha$

$R_k(\underline{u}, \Delta\beta_k)$; $R_k(\underline{k}, \Delta\alpha_k)$

prodotto tra le matrici

$$R_k = R_k(\underline{u}, \Delta\beta_k) \boxed{R_k(\underline{k}, \Delta\alpha_k)}$$

$$\begin{bmatrix} \cos\cdot & -\sin\cdot & 0 \\ \sin & \cos & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\underbrace{\underline{x}_k \;;\; \underline{\alpha}_k \;\text{ o le }\; R_k}$$

$$\downarrow$$

$$\underline{p}_k = \begin{bmatrix} x_k \\ \hline \underline{\alpha}_k \end{bmatrix}$$

$$\downarrow$$

riferimenti $\underline{q}_k = \underline{f}^{-1}(\underline{p}_k)$ cinematica inversa di pos.

- forma analitica
- " " numerica

tempi di calcolo !...

$$\underline{\dot{q}}_k = J^{-1}(\underline{q}_k)\,\underline{\dot{p}}_k$$

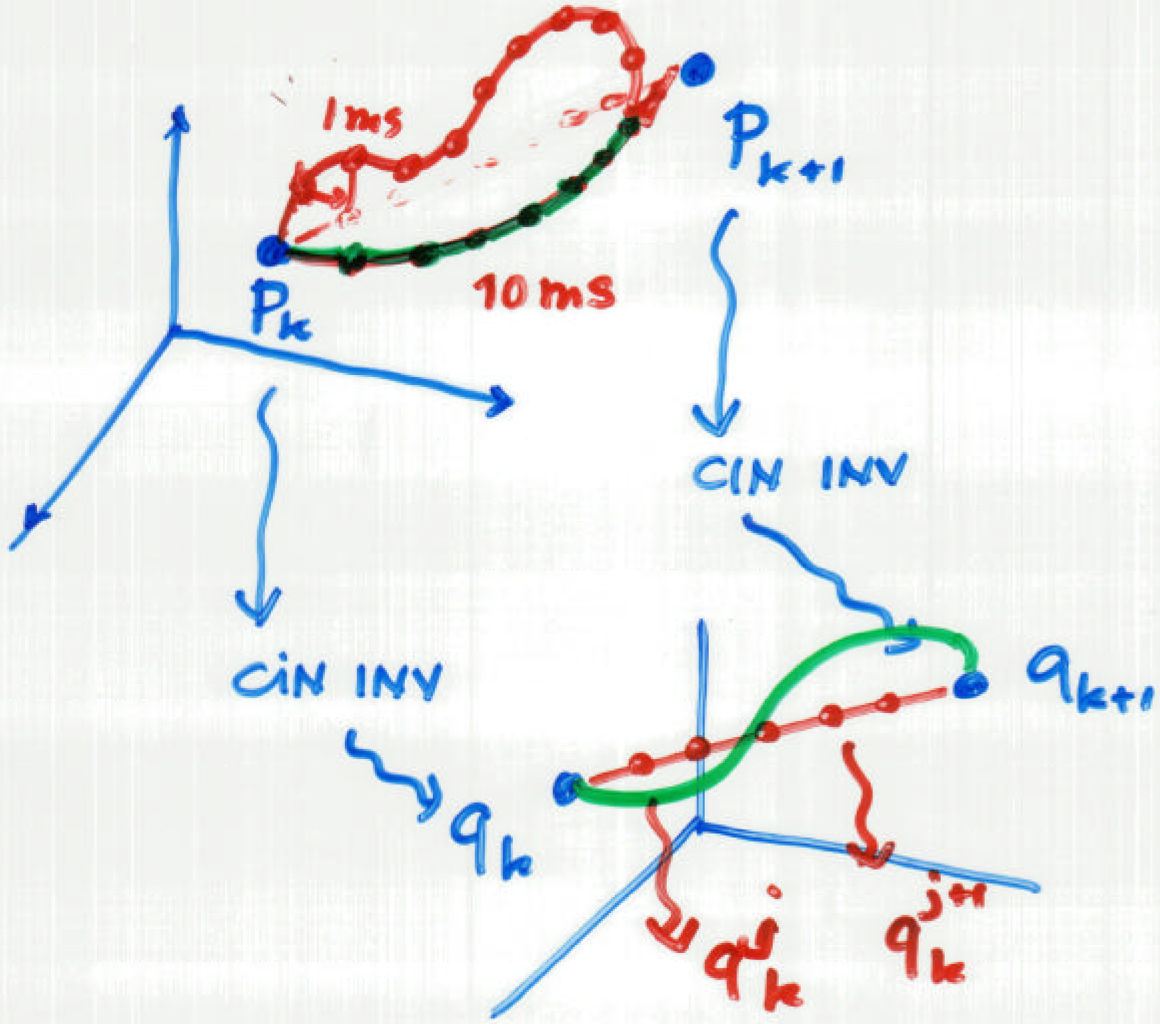
$$\downarrow$$

$$\underline{\Delta q}_k = J^{-1}(q_k)\,\Delta p_k$$

tempi di calcolo

$\underline{q}_k = \underline{q}_{k-1} + \underline{\Delta q}_k$

MACRO-MICRO INTERPOLAZIONE



$\dot{s}_M$?

$\ddot{s}^+_M$? chi li fissa ?

$\ddot{s}^-_M$?

$\underline{p}_f - \underline{p}_0$

$\downarrow$

$$\Delta p_k = p_{k+1} - p_k = (s_{k+1} - s_k)\,\Delta p$$

$$= \Delta s_k\,\Delta p$$

$$\Delta q_k = \boxed{\Delta s_k\,J^{-1}(q_k)\,\Delta p} = J^{-1}\Delta p_k$$

$\downarrow$

$s_{k+1} - s_k$

Δq_i^{max} vincolo per ogni motore

$$\Delta q_{ki} \leq \Delta q_i^{max} \quad \forall i, k$$

$$\Delta s_k\,\underline{J}_i^{T}(\underline{q}_k)\,\Delta p \leq \Delta q_i^{max}$$

$$\Delta s_k \le \frac{\Delta q_i^{max}}{\dot{\underline{j}}_i^T(a_k)\Delta p}$$

$$\Delta s_k^{max} = \frac{\min_i \Delta q_i^{max}}{\max_i \dot{\underline{j}}_i^T(a_k)\Delta p}$$

$$\dot{s}_k = \frac{s_{k+1} - s_{k-1}}{T} \qquad \dot{s}^M = \frac{\Delta s_k^{max}}{T}$$